Tappi

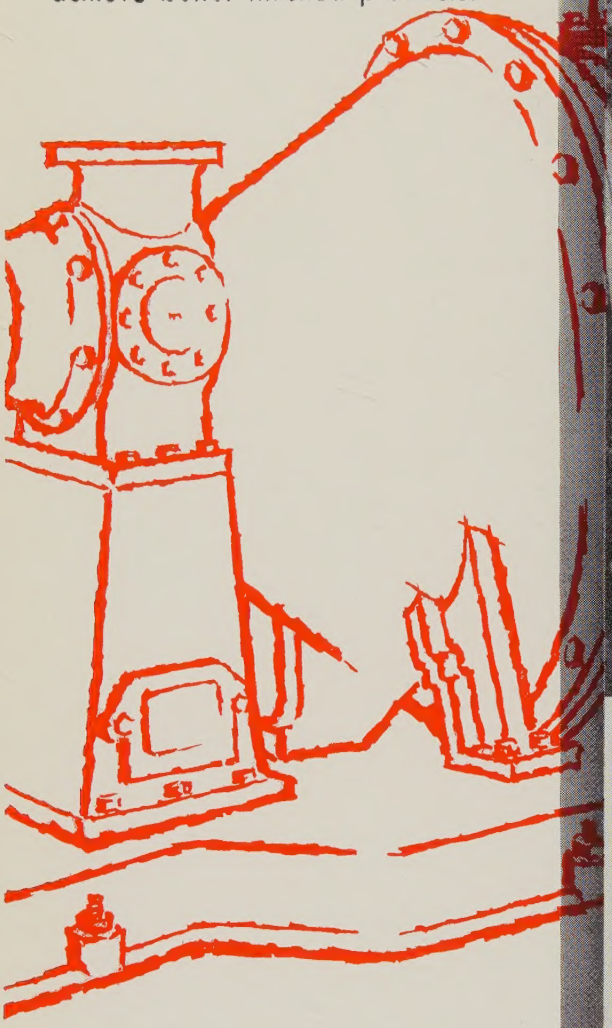
PUBLISHED BY THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY

MARCH 1959

VOLUME 42 • NUMBER 3

Here's the secret!

As in making HAMMERMILL BOND, more and more papermakers are relying on EMERSON CLAFLINS to achieve better finished products.



If you haven't ascertained the performance advantages of these versatile continuous beaters and refiners, write us today.

BOLTON EMERSON
TRADE MARK

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THE EMERSON MANUFACTURING CO. DIVISION
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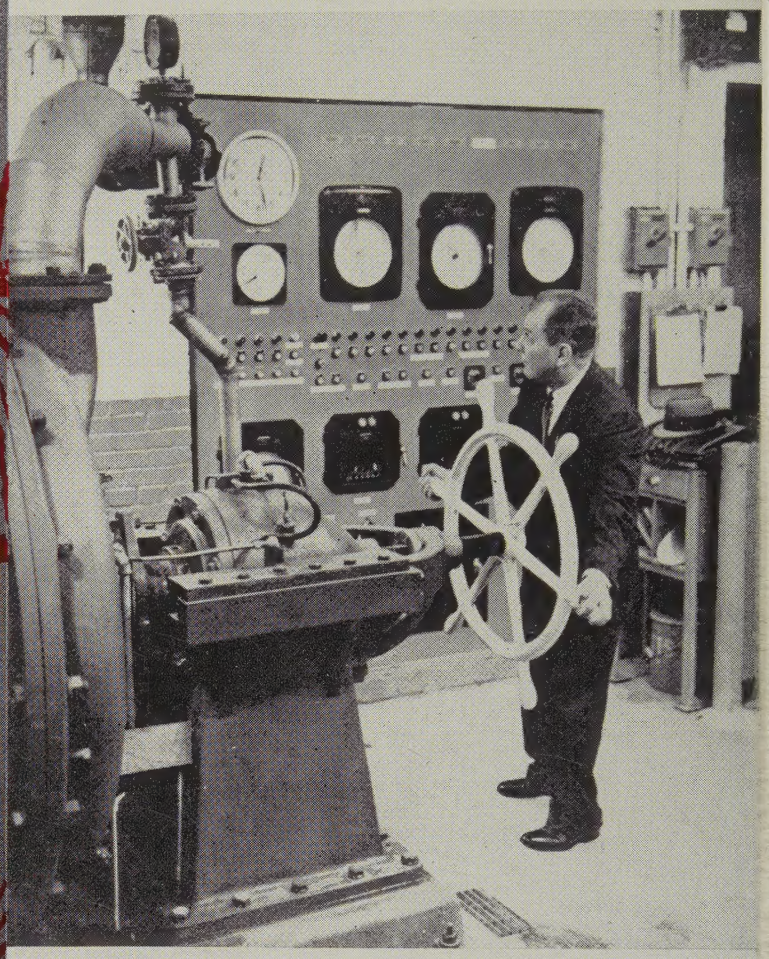

1. The hard way:

Go into the paper mill and learn the papermaking skills that Hammermill experts use in making Hammermill Bond. Find out how to knit fibers together more tightly as Hammermill does with a special machine that beats interlocking "fingers" onto each fiber.

Invent a special centrifugal pulp cleaner—as Hammermill did—to make paper outstandingly clean. Unlock the secret of using hardwoods to make fine papers even finer—as Hammermill has done with its [illegible] Neutracel* pulp.

2. The easy way:

Ask your printer for

HAMMERMILL BOND

COURTESY HAMMERMILL PAPER CO.

3. The sure way:

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Courtesy: Central Soya Company, Inc.

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to get the sizzle of the steak...on paper

It takes a tempting, tantalizing illustration to get homemakers to put a product on their shopping lists. It takes Alpha Protein-processed paper to create this extra dimension of mouth-watering goodness on the printed page.

Frosty whiteness, improved opacity, and a smoother, more uniform surface are inherent benefits derived from using Alpha Protein as a coating adhesive. Moreover, because it speeds production and reduces cost, well-advised coating mill operators are specifying Alpha Protein, the largest-selling adhesive for high-solids coated offset paper.

Count on the Chemurgy Division as a reliable source, because its purified soy protein is carefully checked through all manufacturing stages to insure uniform quality between shipments.

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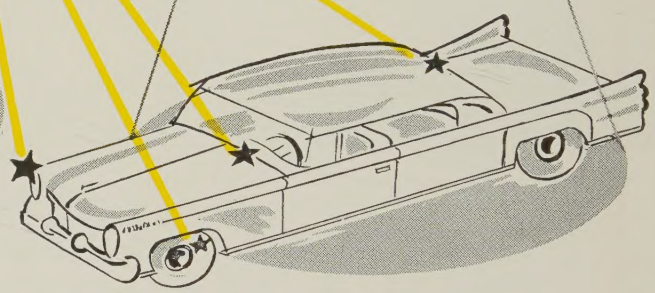
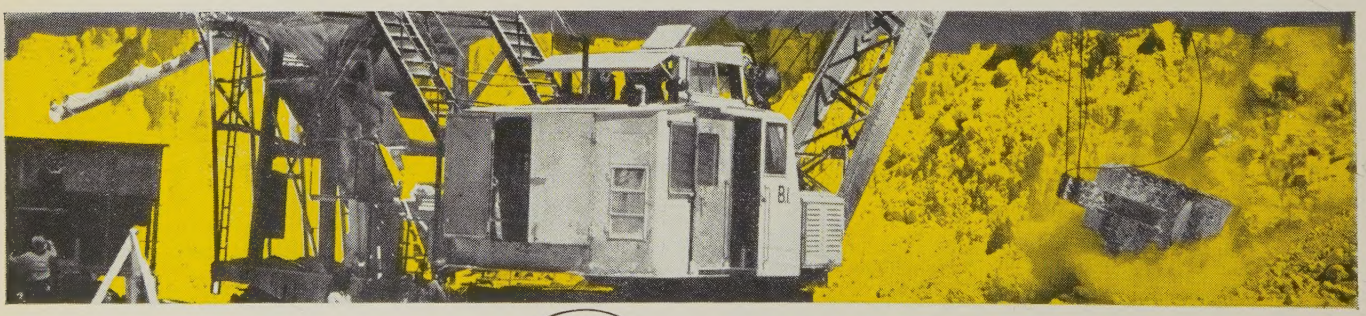


Sulphur enters the automobile picture in two ways: directly and indirectly.

Sulphur, either as the elemental or as one or more derivatives, is used in the manufacture of rubber and rayon. Indirectly, it is used in processing the steel that forms the body. It is used in the plating operation on trim and fixtures. It is deliberately introduced into certain steels to provide better machining qualities.

Recognizing the importance of Sulphur to the basic industries such as the manufacture of automobiles, and to our ever-expanding economy generally, TGS is broadening its service: production, distribution and technical.



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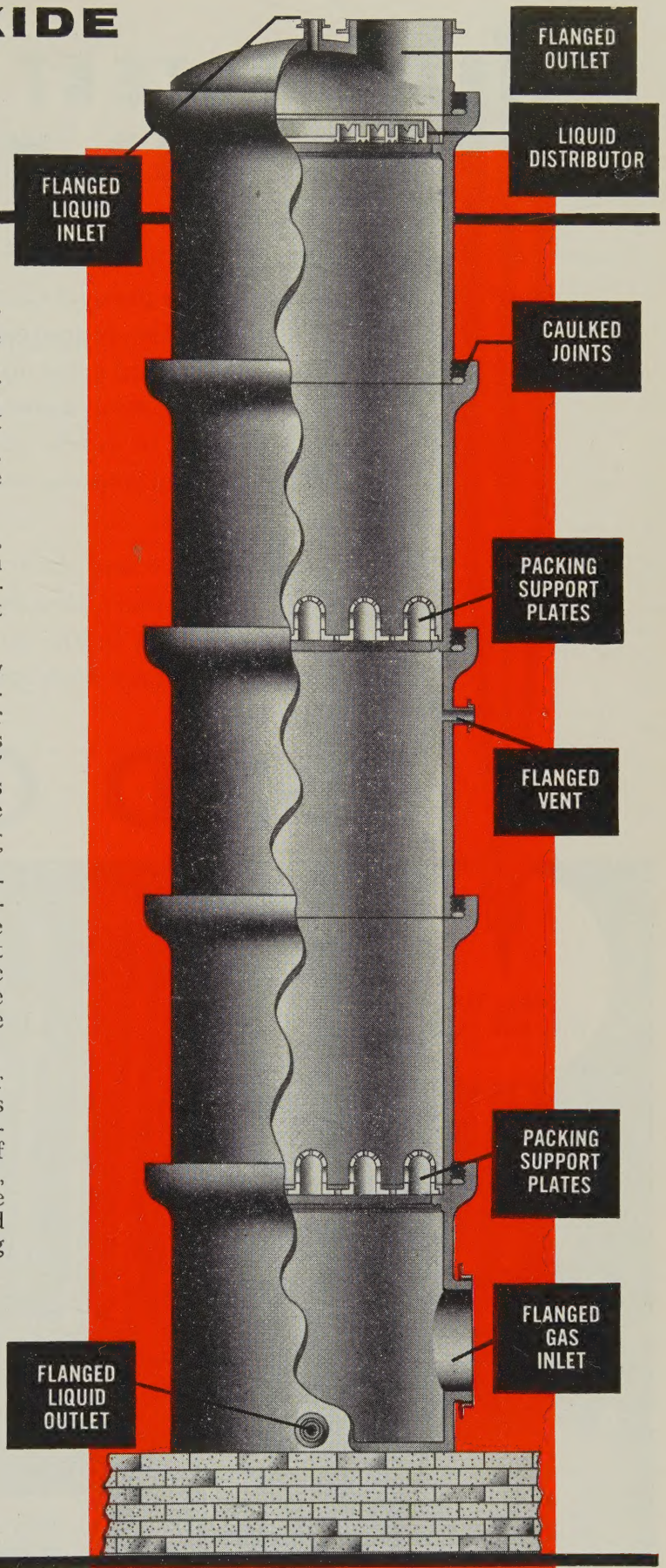
The first chlorine dioxide tower erected in the western hemisphere was engineered and built by U. S. Stoneware in 1950 from our special "Denstone-57" chemical stoneware. Today, virtually every chlorine dioxide tower installed is manufactured by us and made from this special inert ceramic.

From every standpoint: suitability, durability, material and erection costs, "Denstone-57" chlorine dioxide towers offer advantages that rule out any other approach.

Chlorine dioxide towers are quickly erected from standard "Denstone-57" sections. The most popular diameter is 24″, but many towers are made in 18″, 30″ and even 36″ diameters. Heights may range as high as thirty or thirty-six feet. We provide, with the tower, the required number of "Gas-Injection" Weir-type chemical porcelain packing support plates, a liquid distributor designed to handle the liquid rate to be used, and sufficient Intalox Saddle Packing. Ceramic pipe and fittings of the same "Denstone-57" chemical stoneware body are also available.

Chlorine dioxide towers is another typical example of U.S. Stoneware's continuing research in packed column technology. The results of these engineering investigations, and our practical "know-how" are always available, with no implied obligation, to design and operating engineers.



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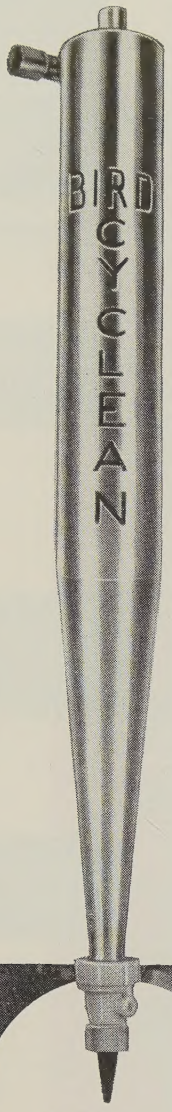

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The Bird Cyclean is a free vortex, drop-in-pressure cleaning unit of superior design that is providing pulp and paper makers with another potent weapon in the campaign to reduce rejects and breaks and improve quality and uniformity.

Cycleans take out shives and specks . . . improve fibre hydration . . . reduce breaks on the machine . . . reduce wash-ups . . . increase wire life . . . increase machine output per hour and per week.

Cycleans are proving outstandingly successful on both virgin and waste stocks. Ask us to supply recommendations, layouts and estimates.

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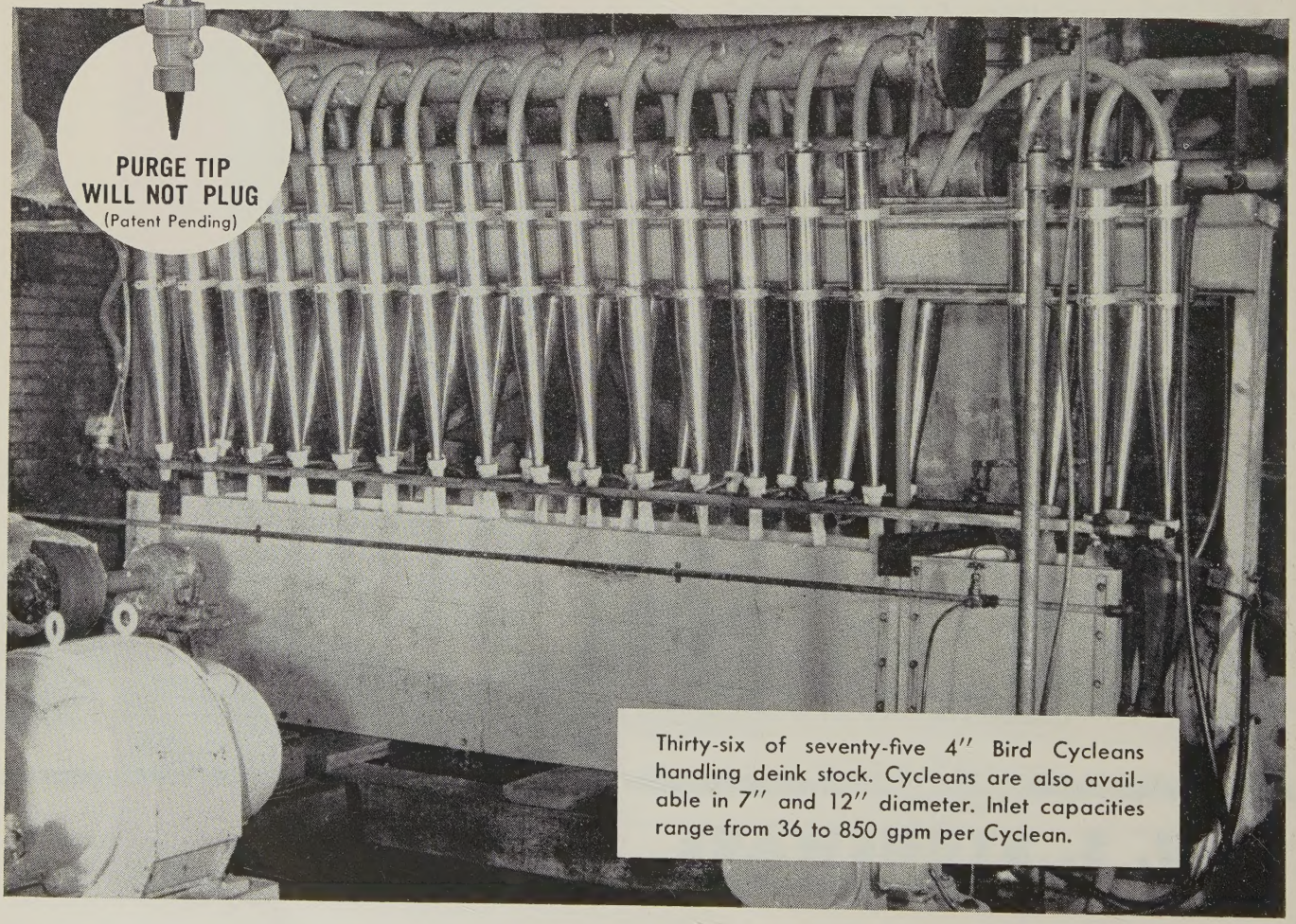
(Patent Pending)



Thirty-six of seventy-five 4″ Bird Cycleans handling deink stock. Cycleans are also available in 7″ and 12″ diameter. Inlet capacities range from 36 to 850 gpm per Cyclean.

MARCH 1959

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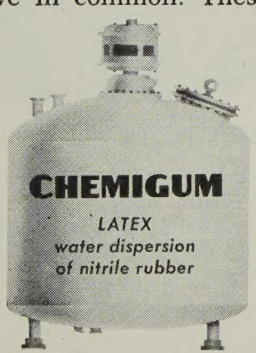

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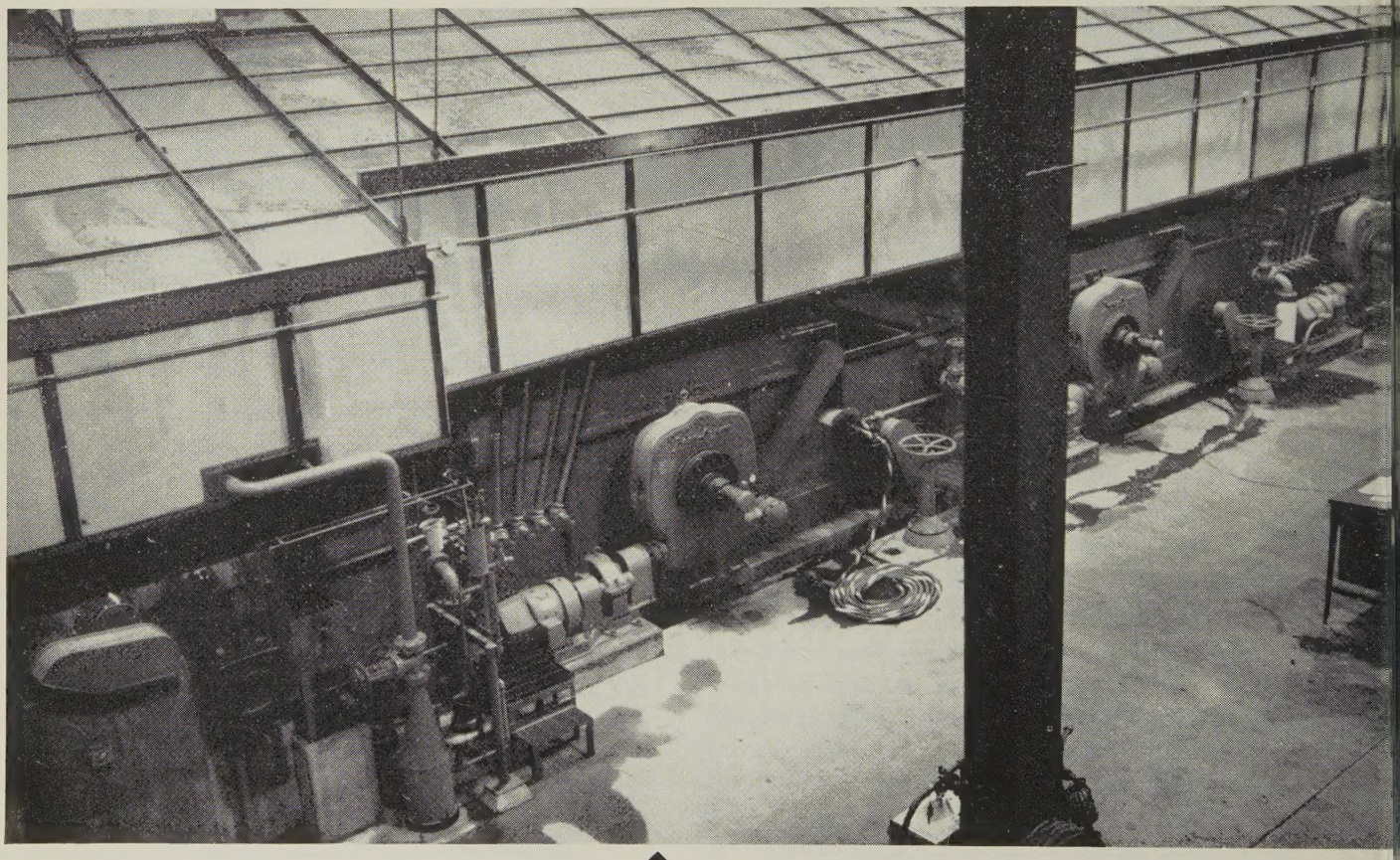

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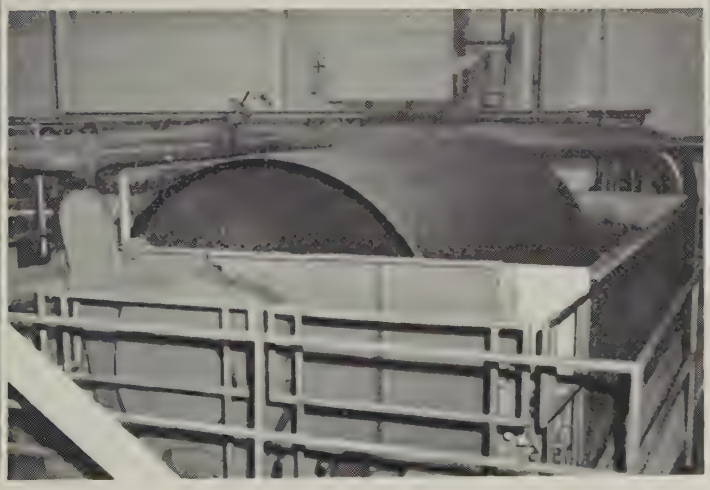

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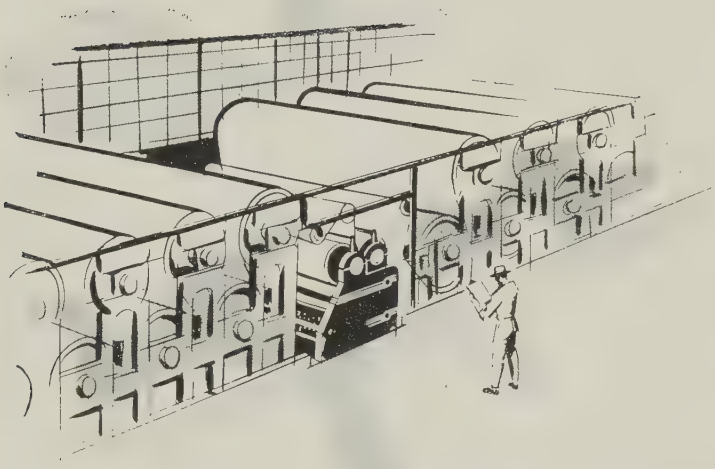

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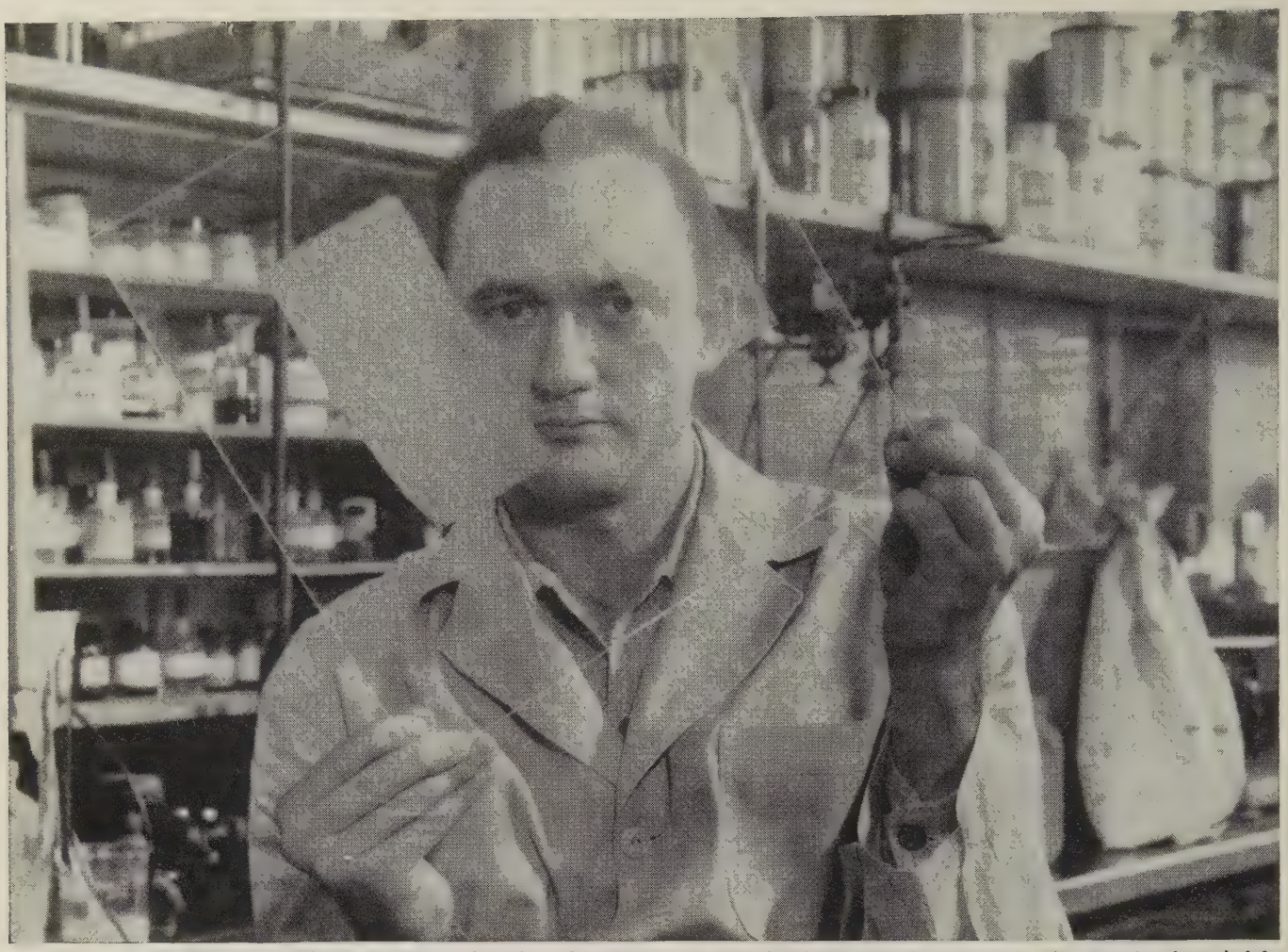

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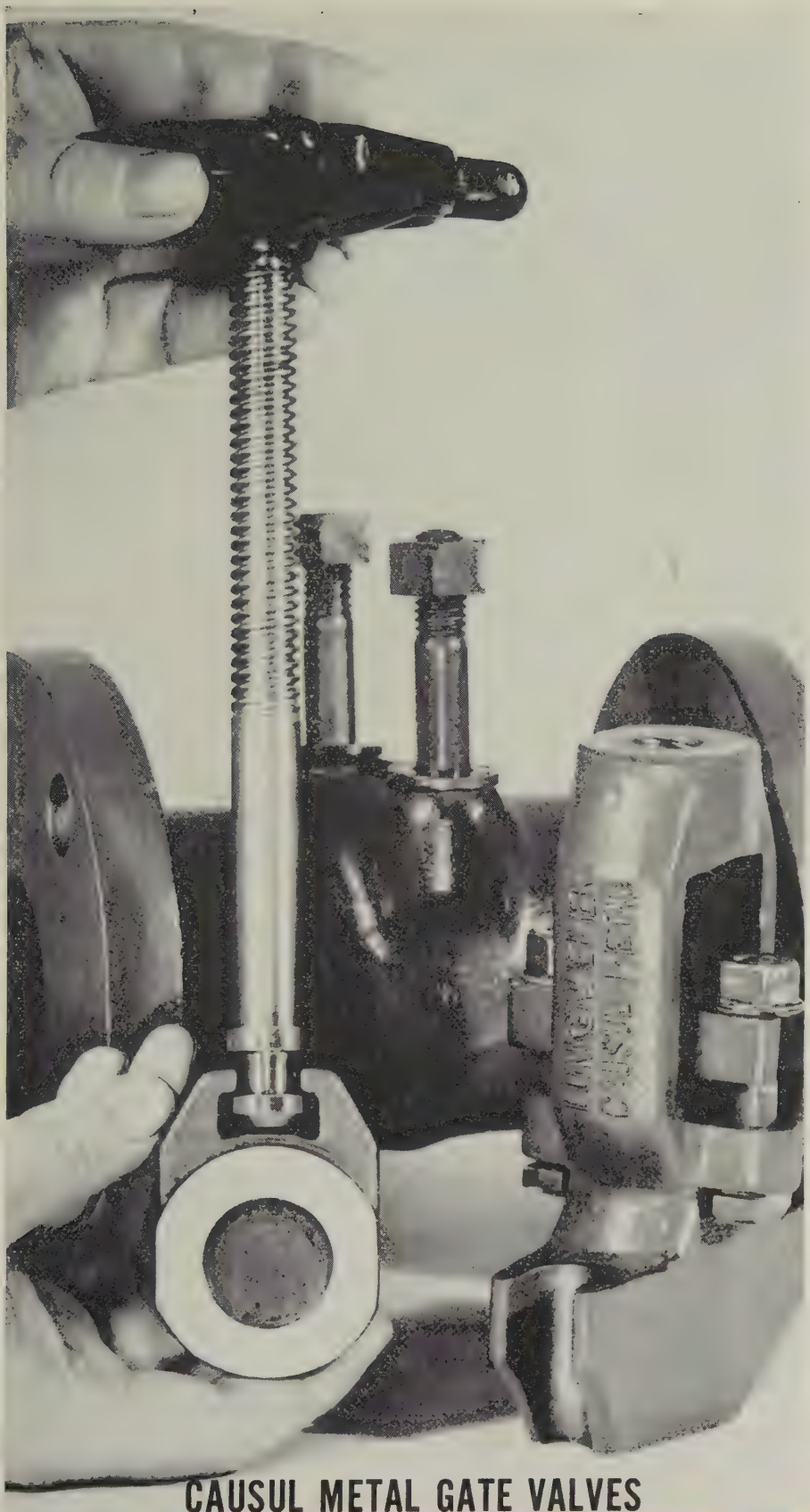

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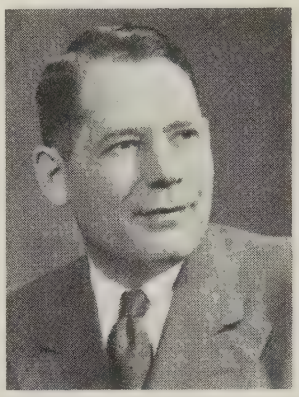

GENERALLY it is the custom of a retiring TAPPI president to use this occasion to review the Association's activities during his term of office and to speculate on the opportunities immediately ahead. In the spirit of this tradition we could say with pride that TAPPI in 1957 and 1958 has been a constructive force in ever-widening fields of activity, and that it can look forward with confidence to the challenges it will undoubtedly face in 1959. But it is more appropriate that we consider instead an aspect of our activities which is little known to most of our members. Even though this activity is not new, its full development lies almost certainly beyond the few years immediately ahead.

I am referring to our overseas members. Their contributions to our efforts are numerous and are felt in many ways. You see some of their technical papers published in *Tappi*. You find frequent reference in the magazine to meetings of the Study Group of European TAPPI Members, of the Association of the Italian Members of TAPPI, and of other national or international groups in which our members participate. And at our own conferences you note increased attendance by these representatives from other countries.

These activities remind us forcefully that TAPPI is not simply a national organization whose interests and responsibilities are confined to our own 49 states. There is nothing in either our association's name or its constitution which limits us geographically. In the past we have chosen for good reasons to concentrate the energies of our association on matters of primary concern to our members in this country. Such emphasis has born excellent fruit. No one questions the significant role played by TAPPI in advancing the technology of our paper industry and in gaining greater recognition of the importance of technical men in our operations.

In spite of this concentration on matters of national concern, TAPPI's stature as an international association has grown at an astonishing rate. Many of you will be surprised to know that over 25% of our individual members and 45% of our corporate members are from outside the United States. The rapid growth of TAPPI membership in this country during the postwar era is no more dramatic than the increase in European membership from 500 to 1000 during the 5-year life of the European Study Group.

W. D. HARRISON, President, Allied Paper Corp., Kalamazoo, Mich.

Such expansion is evidence of the growing realization that in technology as well as sociology "no man is an island unto himself." As an industry we progress faster when we work cooperatively rather than selfishly alone in the many areas of interest.

Such expansion in overseas membership is particularly noteworthy when you recognize that these men are unable to participate effectively in many of our activities. They have no technical committees or local sections; only a small number are able to attend our meetings in this country; many are unable to obtain full and accurate translations of the numerous publications they receive.

It is not surprising that there were occasional requests in the years preceding 1954 for TAPPI to establish local sections in other countries so that technical men could meet together and discuss common problems. Such requests were studied carefully by the Executive Committee. Believing that the petitioning groups lacked continuity of leadership, the Executive Committee declined all of these early requests.

In 1954 a somewhat different proposal was advanced. Herman Wenzl, a TAPPI member and prominent consultant in Lucerne, Switzerland, suggested the formation of a study group of European TAPPI members. This group would hold periodic meetings in Europe similar to TAPPI conferences in this country. At such meetings members would present technical papers, discuss operating or scientific problems of common interest, and visit nearby mills and laboratories.

Mr. Wenzl's suggestion was based on an initial survey which revealed that about 500 TAPPI members resided in European countries, and that many of these members were not members of the existing national pulp and paper technical societies in their countries.

His proposal was considered by the TAPPI Executive Committee with mixed feelings. The idea of encouraging any group that could benefit by a discussion of technical topics relating to the industry was appealing. On the other hand, since TAPPI had maintained amiable relations with the established technical associations in Europe, it was felt that such encouragement could be misunderstood. Consequently, no statement of policy was formulated. The establishment of the group was neither sponsored by the Association nor was it discouraged in any way.

Mr. Wenzl's proposal, however, found immediate support in some European countries, particularly those which did not have strong technical associations of their own. In still other countries the plan was regarded with reserve bordering at times on open hostility.

Several objections to the proposed Study Group were advanced. Men in countries with well organized technical associations felt understandably that their associations were adequately meeting the needs of their

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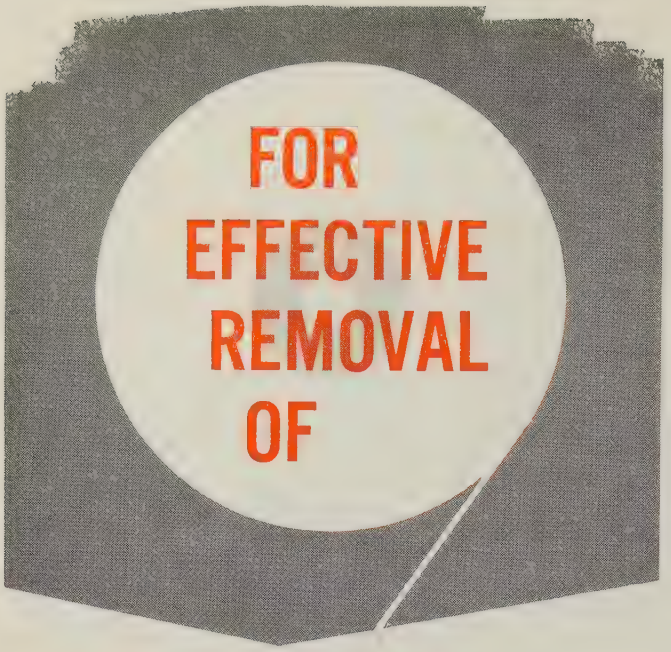

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technical men, and that cooperation between existing associations already allowed for the efficient exchange of information. The entry of TAPPI was considered an unnecessary duplication of effort. Other people feared that TAPPI would attempt to make Europe a recognized branch of our Association, thereby decreasing the stature of their own national associations. They foresaw an unhealthy competition for papers to be delivered at the technical meetings of their national associations and the TAPPI Study Group. Others suspected that organized TAPPI activity would eventually lead to the acceptance of TAPPI Standard testing methods in Europe, and some argued that language barriers and deep-seated nationalistic sensitivities prevented effective international action by TAPPI or any other cooperative group.

In the face of such opposition the formation of the Study Group might have been delayed for an indefinite period, but the proposal appealed strongly to Georges Franck, president of the Cartonnerries de la Rochette in Paris. Mr. Franck had visited the United States frequently and had become enthusiastic about American methods. He also had attended meetings of TAPPI and discussed with Dr. Macdonald details involved in organizing and operating a similar organization in France. These discussions lead to the forming of the A.T.I.P. (Association Technique de L'Industrie Papetiere) which has become an excellent technical society.

In May 1955, in connection with the annual meeting of A.T.I P at Grenoble, France, Mr. Franck sent out invitations to European members of TAPPI to attend a technical conference at Paris immediately following the Grenoble meeting. The response to his invitation was better than had been expected. A large proportion of the TAPPI members in Europe favored the establishment of the Study Group. A number of these people were able to attend the Paris meeting, where a program of technical papers was presented and where an organization was established. Its governing body represented each of the European papermaking countries.

A year later a second conference was held in London. This 5-day meeting, attended by 180 TAPPI members, featured 12 technical papers and five plant tours. This meeting was followed by a 1957 conference at the Austrian university city of Graz; 170 TAPPI members representing 13 European countries, Canada, and the United States participated. Twenty papers were presented during the three days of technical sessions, and these were followed by two days of plant tours. Last year the fourth annual meeting was held in Turin, Italy. A record number of 254 TAPPI members from 16 countries attended this meeting. *The World's Paper Trade Review* reported on this meeting in its October 2nd issue as follows:

"Members attending the Fourth Annual Congress of the Study Group of European TAPPI members, held in Turin from September 14–19, following the two-day programme of technical sessions, visited a number of Italian paper industry plants and research institutions.

"This Fourth Annual Meeting of European TAPPI members was generally acknowledged to be among the most successful of the series. As reported in our last issue, the Italian Group Committee, under the presidency of Dr. P. Bersano, organised the conference with great skill and with meticulous attention to the nu-

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merous details which in sum make all the difference to the success of this type of meeting. The united effort of technical men of the Italian paper industry, under the European TAPPI banner, in mounting a conference of this character, has done much to further the prestige of the European Study Group and should ensure lively interest in next year's meeting scheduled for the first week in June at Noordwyk in Holland, where it will follow the EUCEPA meeting."

It is obvious that in the short history of the European Study Group, it has made great progress. For four years in succession this group has staged highly successful conferences in different European countries, to the considerable benefit of the whole European pulp and paper industry. Their achievement is great in light of the obstacles faced and the absence of any direct support from our Association. The European Study Group is clearly the product of dedicated individual members, men of the same vision and energy as those which founded TAPPI over 40 years ago.

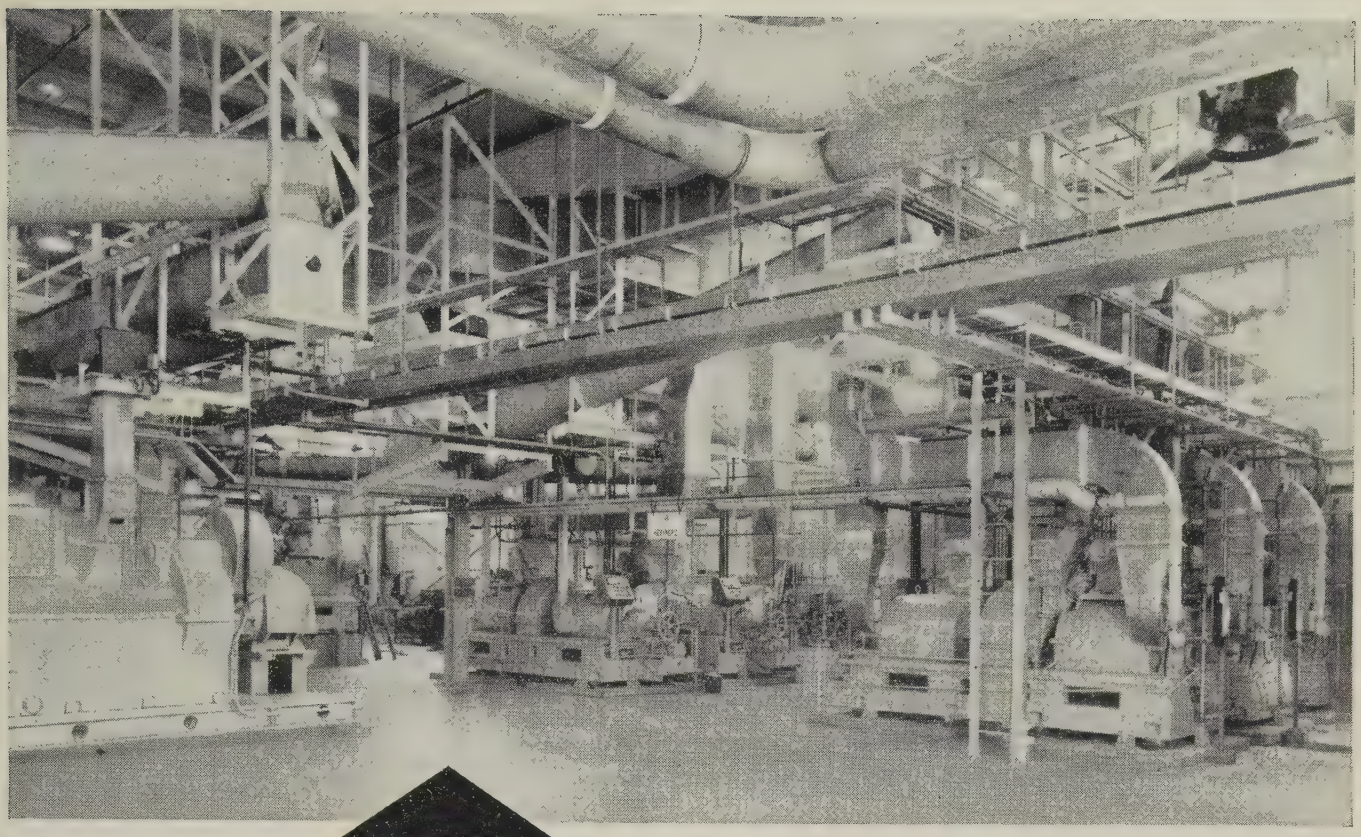
A further step in promoting international cooperation was the formation of EUCEPA, a European Liaison Committee for Cellulose and Paper. The name is derived from the words EUropean, CEllulose, and PAper. This international committee was founded in 1957 to develop and disseminate technical information in the field of pulping and papermaking by the cooperative action of the various chemical and engineering associations of European papermaking countries. The central committee is composed of the chairman or secretaries of these various national associations. At the committee's invitation a representative of the TAPPI Study Group has been added to the central committee, so that the Study Group has the same standing in EUCEPA as that of the national associations.

EUCEPA staged a very successful meeting in Darmstadt last year on "Cellulose Chemistry." This year another symposium will be held on June 1–3 on "Straw Pulping" at Noordwijk near The Hague in the Netherlands. Significantly, this meeting will be followed immediately by the 1959 conference of the Study Group of European TAPPI members assembled at the same location to discuss "The Use of Short Fibered Pulps in Paper." It is hoped that these two 3-day meetings will attract a record attendance, and we heartly applaud this example of cooperative activity involving EUCEPA and our European members of TAPPI.

At this point I should tell you that the Italian TAPPI members petitioned your Executive Committee some time ago for a local section charter. The Executive Committee has been impressed with the vigor of the organizing ability of that group and their earnestness in setting up the local section. They have demonstrated their ability to organize and carry out successful technical meetings of high quality.

Therefore, I am pleased to announce to you that the Executive Committee of TAPPI has granted a charter to its first overseas local section—the Italian local section. I am sure that all of our members everywhere join with me in sending the Italians our very best wishes.

Now getting back to the European Study Group and EUCEPA it would be quite inaccurate to imply that these highly commendable groups have sailed into quiet waters with all of their problems behind them. This is not at all the case. The obstacles ahead are formidable



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ones which will require the understanding and good will of the men involved. There is still wide disagreement on how best to promote cooperative efforts involving various mills and various countries. More basically, there is still considerable resistance in many quarters to the idea of cooperation of any type.

In many countries the situation today is comparable to that which existed in the United States during the early years of TAPPI. There was little communication then between competing companies. Rival papermakers often deliberately avoided contact with each other. The idea of discussing common problems with competitors did not take hold overnight. It took many years for managements in the United States to recognize the benefits of open discussions and cooperative action on common problems.

In this area of international activity the Executive Committee has chosen to move slowly and deliberately, not because the Association is disinterested, but rather because there has been no clear indication of how TAPPI could offer its assistance. We have a responsibility to help our overseas members in the fulfillment of TAPPI objectives; yet we recognize clearly that such fulfillment can not be attained if it involves the loss of the goodwill of our sister associations in these countries. This, we do not want to do.

Both the Study Group and EUCEPA have made great strides and TAPPI is keenly interested in their welfare and continued growth. Their objectives in Europe so closely parallel our own in this country that we will weigh carefully and thoughfully their suggestions as to how TAPPI might assist them in their future activities.

I want to make it crystal clear, however, that TAPPI has no purpose or desire to organize in other countries. Yet it will always listen to the requests of its members and will act on such requests, according to their individual merits.

TAPPI's success today is based on the willingness of its members to share experiences and discuss common problems. We believe deeply that such exposure to other men's minds has aided in the development of our technical men, and that these men in turn have contributed signally to the advancement of our industry.

We have every reason to believe that this same spirit of cooperation will be effective on an international scale in raising the standards of the paper industry everywhere and in building bridges of good will between men and between nations.

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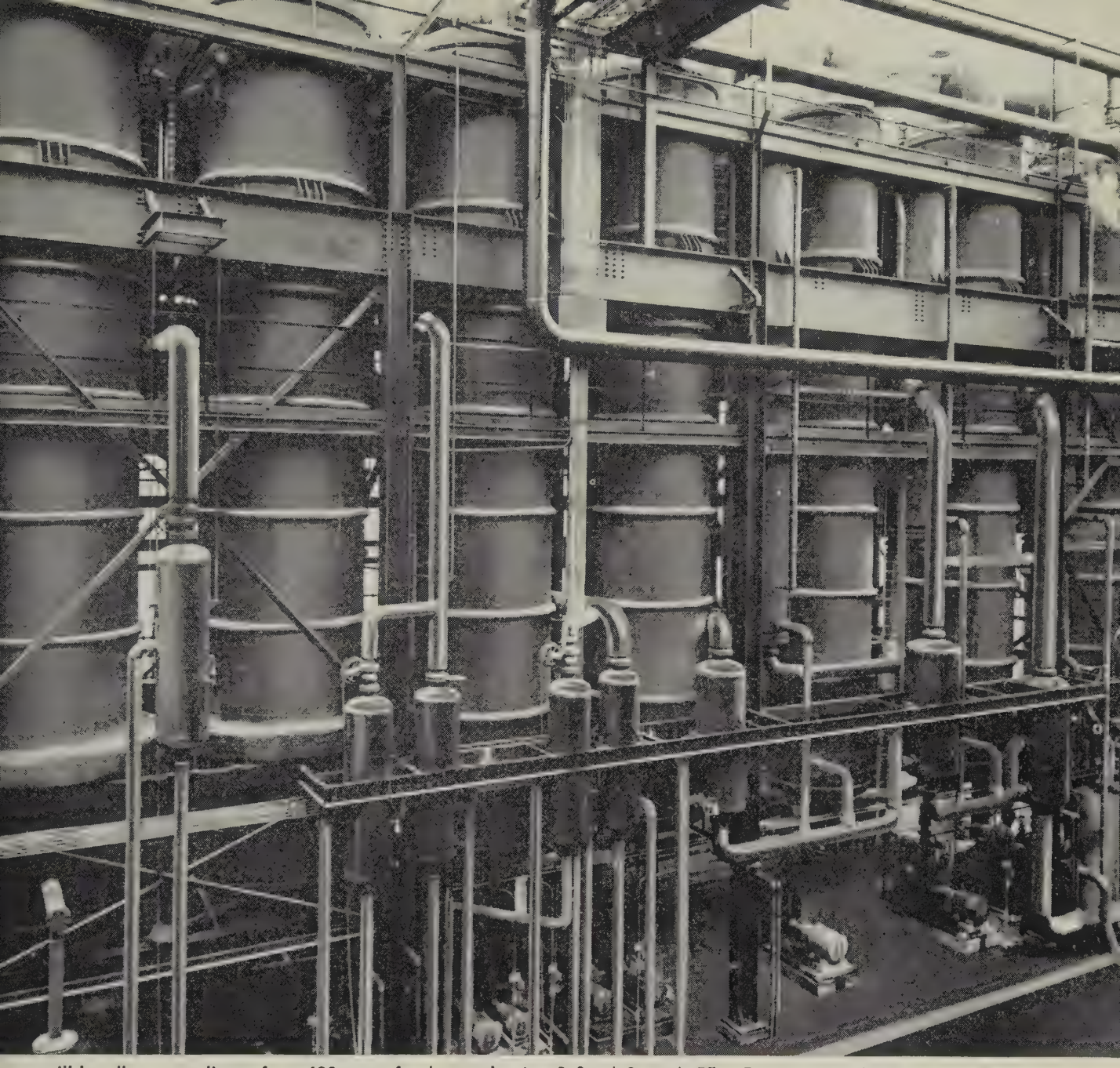

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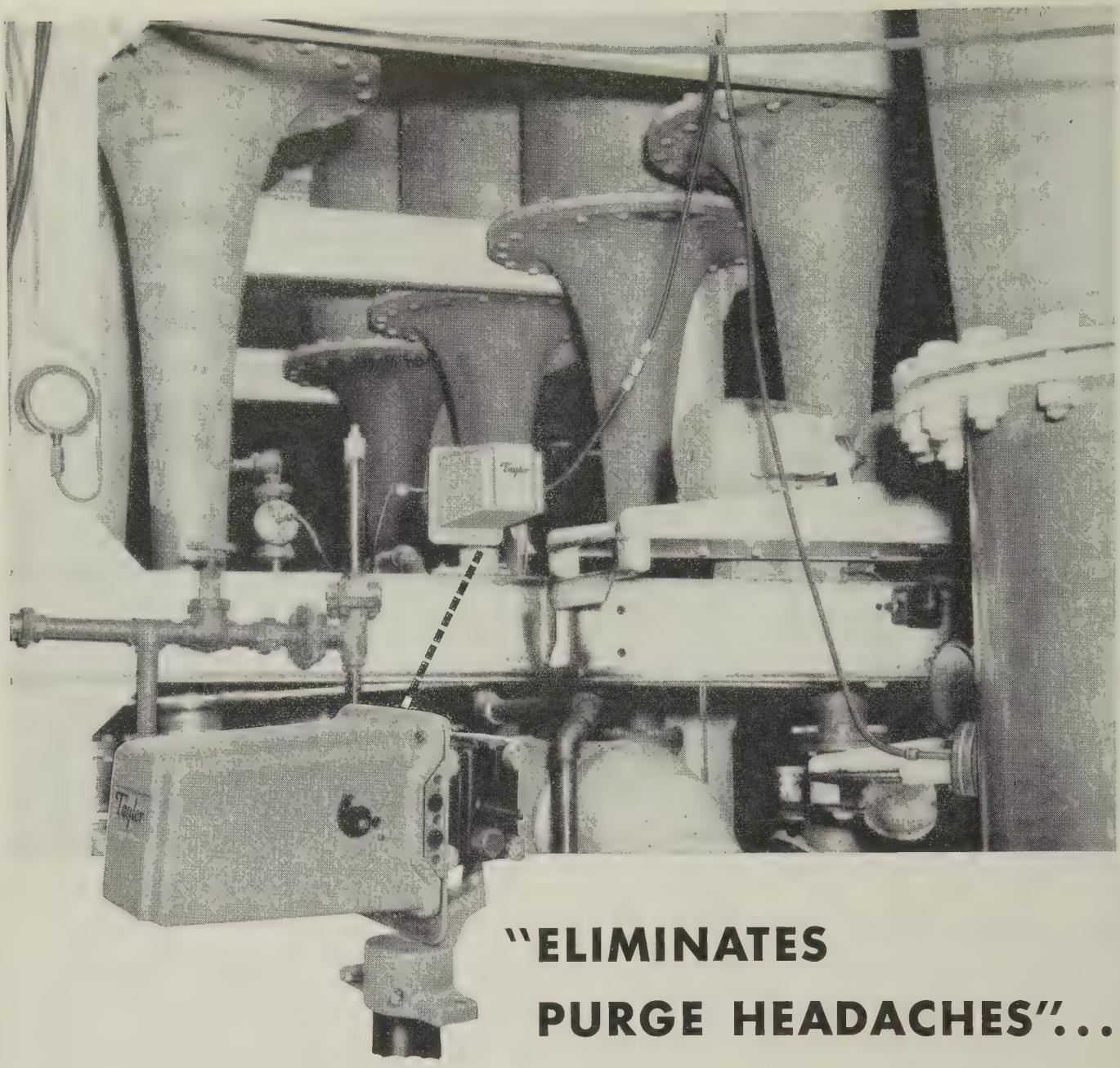

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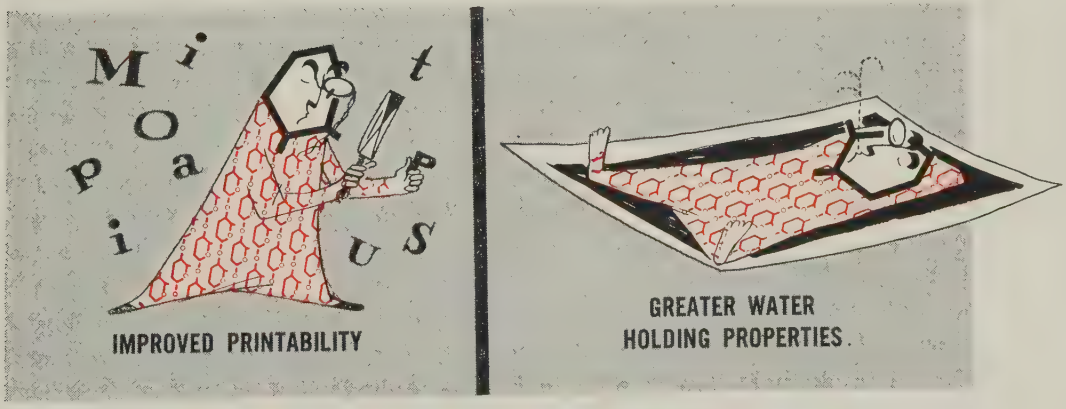

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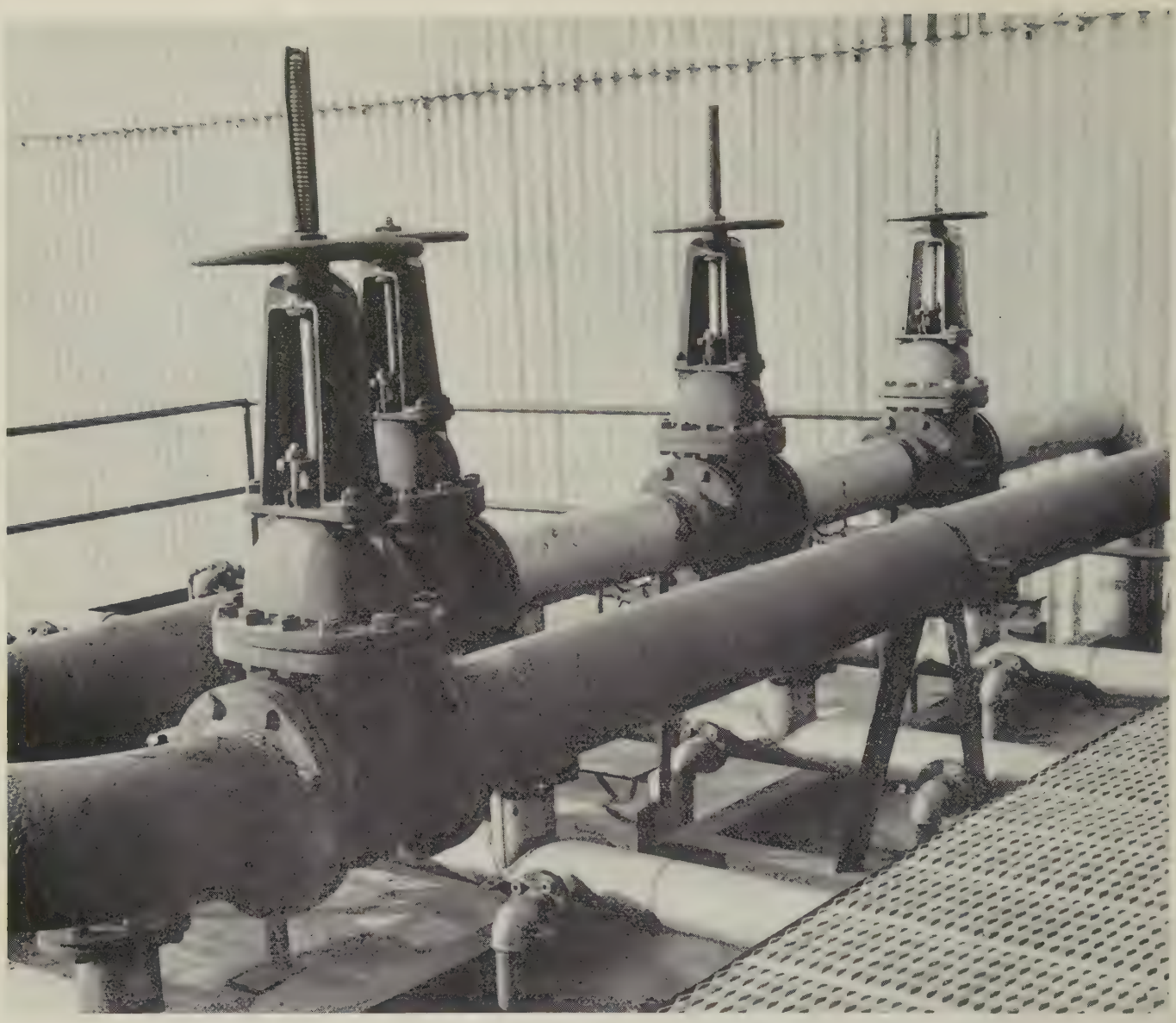

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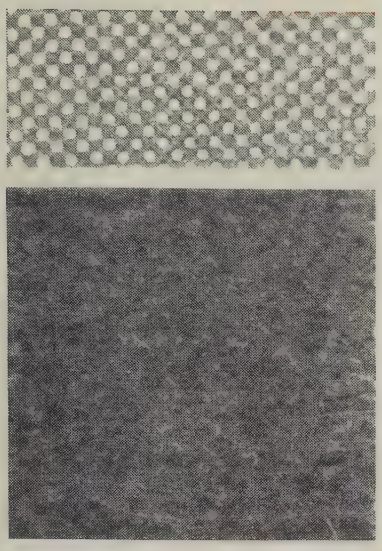

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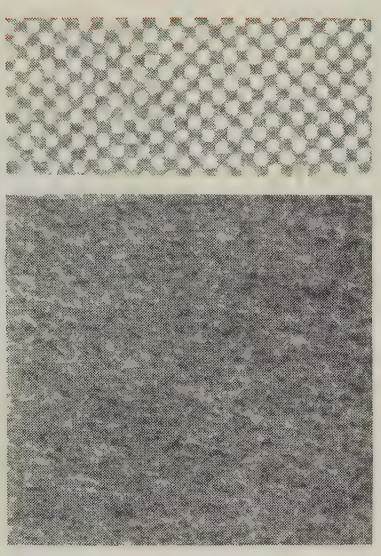

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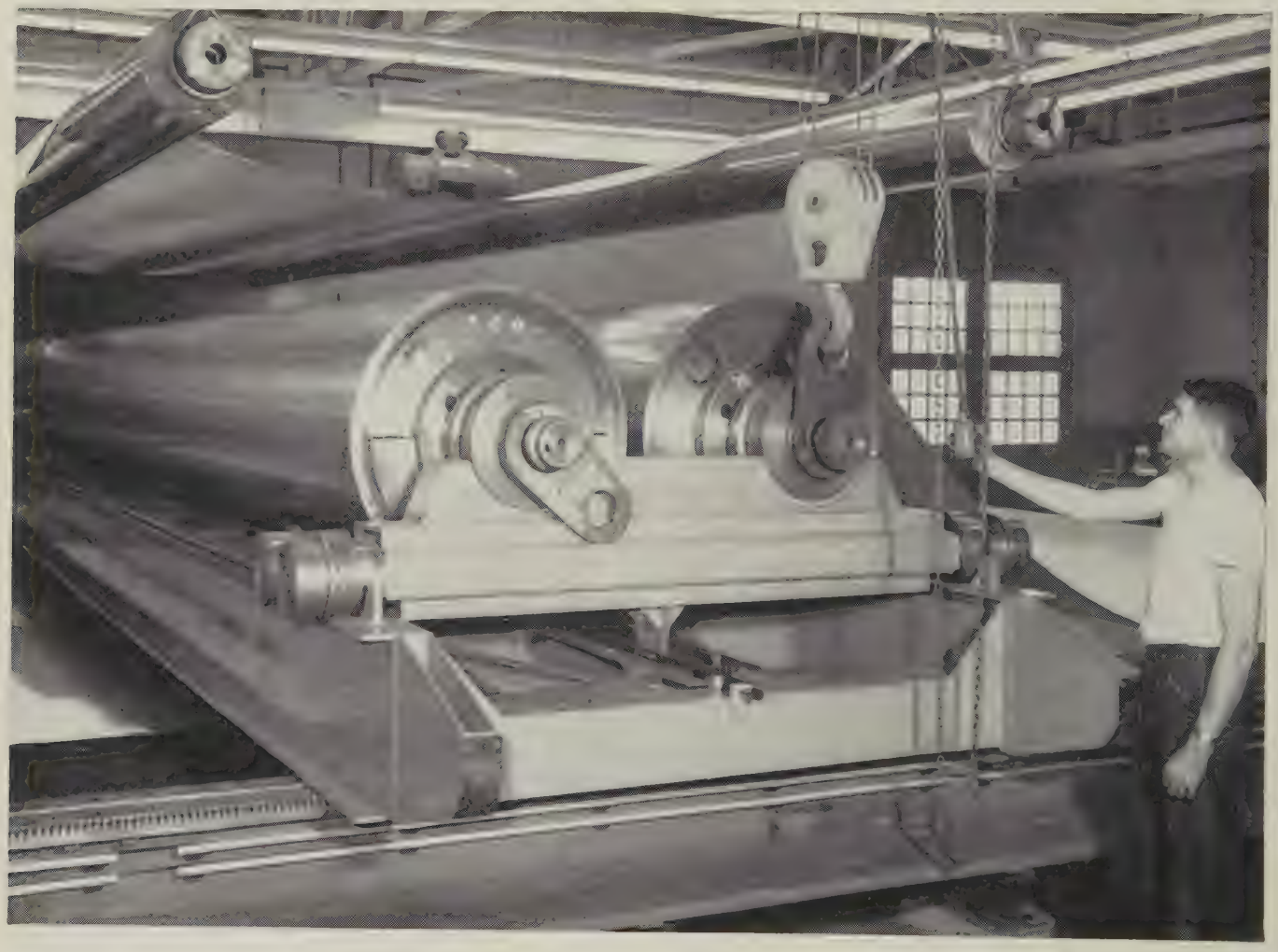

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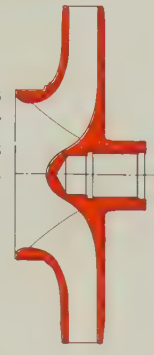
For normal stocks up to 4% consistency

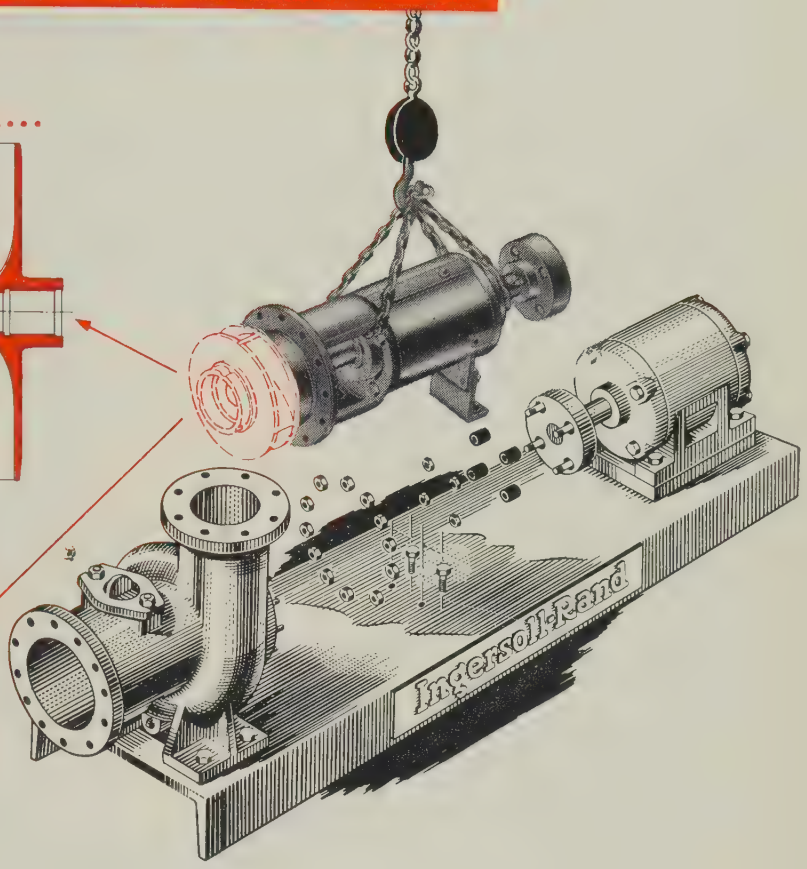
Note that the width decreases from center to periphery. For stocks with concentrations as high as four per cent, this impeller is the most suitable.



B. DIVERGING IMPELLER...

For high consistency or entrained-air stocks

Note how width *increases* from center to periphery. Material cannot enter fast enough to replace ejected material, and a vacuum forms between blades. Any entrained air or gases pass through the vacuum space without binding; solids and slurries pass through without abrupt acceleration.



You can switch this pump from normal to heaviest stock service...

simply by changing impellers and casing rings!

Here, for the first time, is a centrifugal pump which can be converted from handling normal stock (up to 4% consistency) to your heaviest stock . . . up to 10% consistency, containing large amounts of entrained air or gas. *All you do is switch impellers* and casing rings on the Ingersoll-Rand *All-Purpose* stock pump: The conventional impeller and the patented diverging impeller (see explanation above) are completely interchangeable.

All other parts are identical, which means you can cut your spare parts inventory at least in half . . . because one basic pump can be adapted to handle any type stock. This gives you unprecedented flexibility in changing stocks and varying concentrations.

When you convert to the exclusive I-R diverging impeller, you have a pump which will not clog or vapor bind, which is self-venting and self-regulating. It will easily handle industrial liquids which other types of centrifugal pumps cannot handle.

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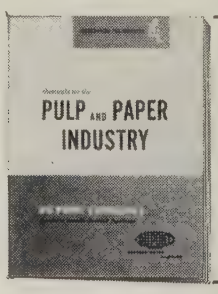
. . . THROUGH CHEMISTRY



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Wilmington 98, Delaware

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from a trickle...

to a torrent

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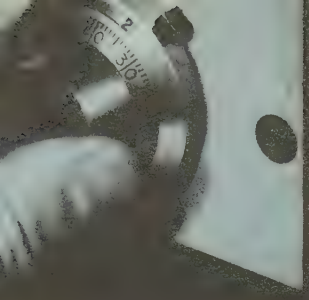

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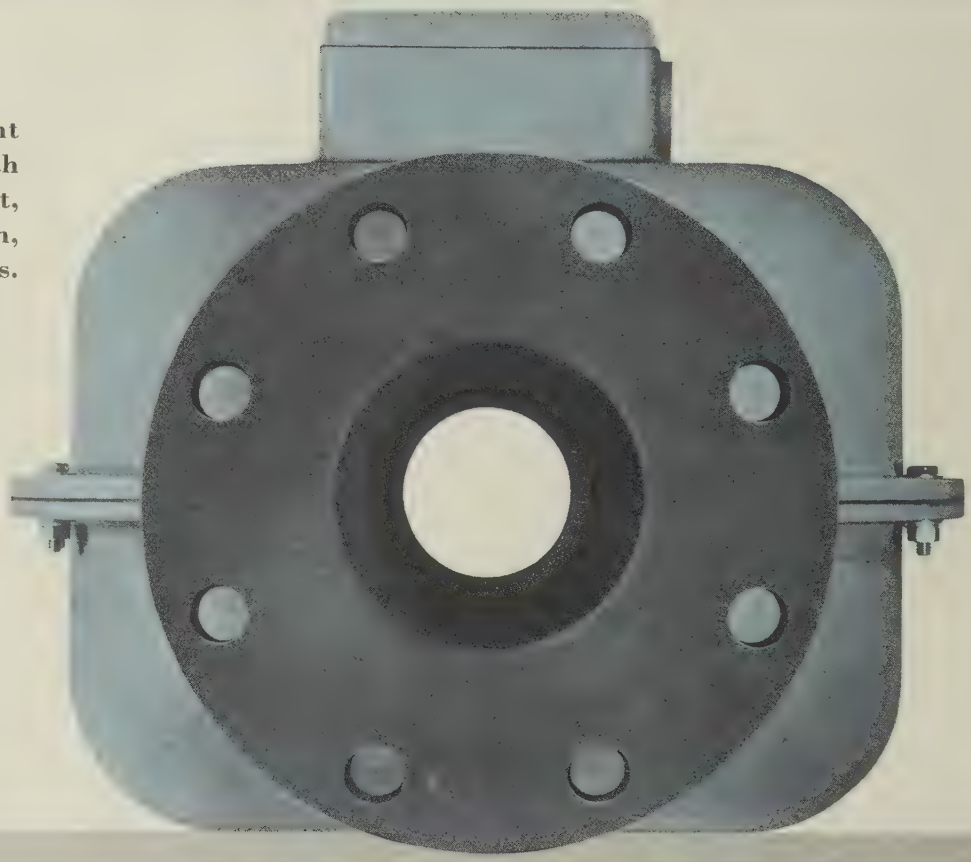
A natural for basis weight control. Meters stock with no obstructions. Perfect, too, for caustic, bleach, alum, clay and all liquors.



A turn of a dial gives you full-scale recording for *any* flow rate from 1 to 30 feet per second and permits operation at optimum chart position. This flow range flexibility costs you no more . . . it's an "extra" that's built into every *Fischer & Porter* Magnetic Flowmeter.

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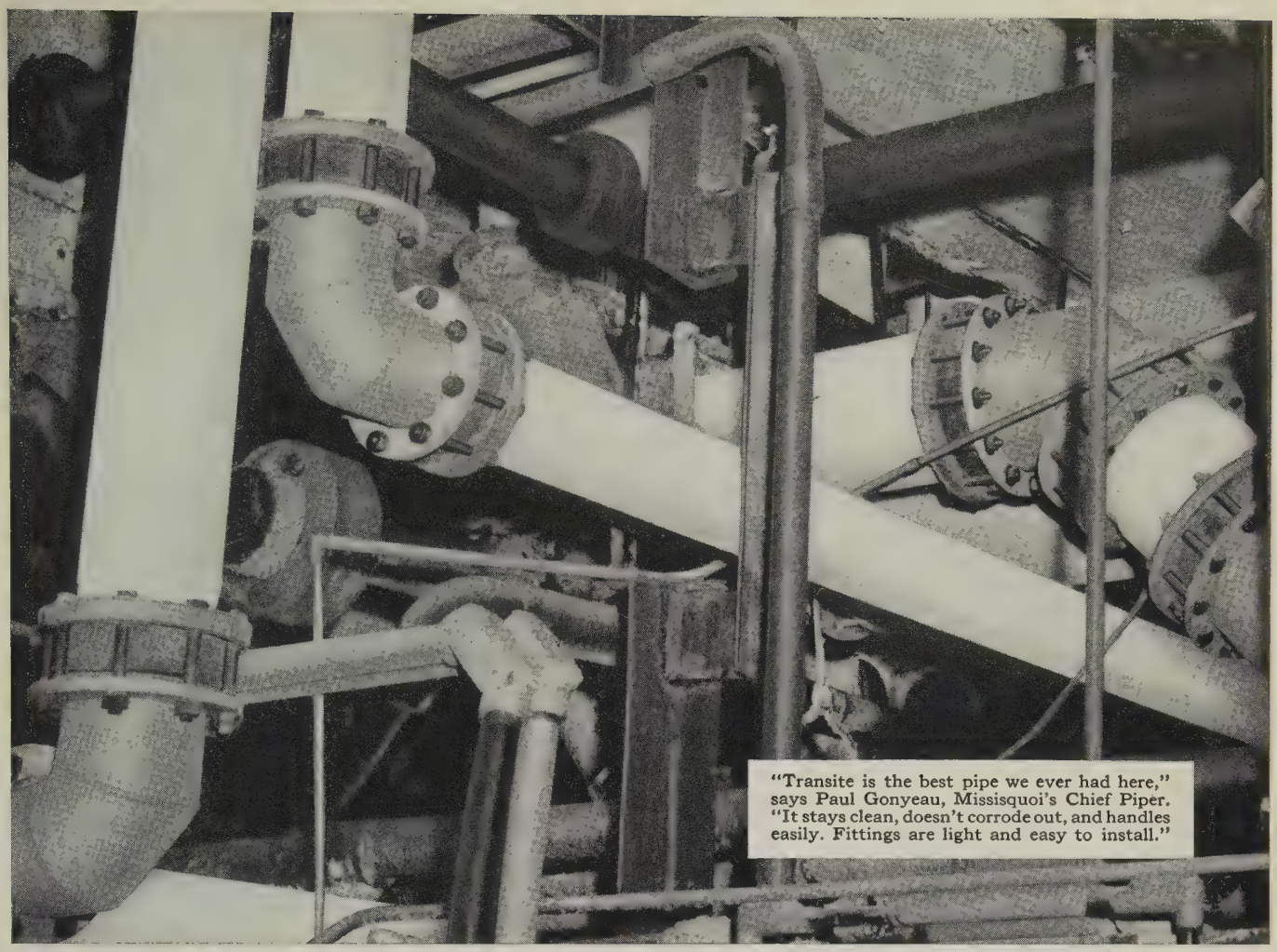
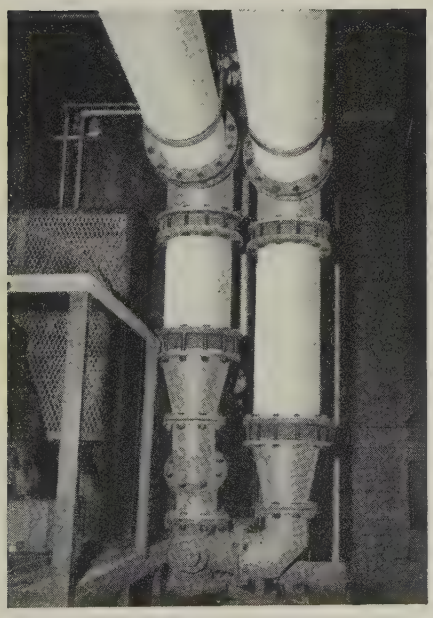


"Transite is the best pipe we ever had here," says Paul Gonyeau, Missisquoi's Chief Piper. "It stays clean, doesn't corrode out, and handles easily. Fittings are light and easy to install."

"Of the 4 stockline materials we've used . . . we rate Transite best in economy, workability, and resistance to stock build-up!"

Says Mr. R. P. McGinley, Plant Engineer, The Missisquoi Corp.



Only asbestos-cement touches the process liquids. Transite-lined fittings permit an all-Transite system—combine installation savings with proven resistance to stock build-up.

Until 1955, the Missisquoi Corporation, Sheldon Springs, Vermont, had never used Transite® Pipe. Earlier installations of three other materials had proved unsatisfactory, either from an economic or service standpoint.

"It became necessary," says Mr. R. P. McGinley, Plant Engineer, "to think of another pipe material because of the cost, weight and handling difficulty of one material, and the excessive cost of the second. A third had also been tried, but because of the acidity of some of our furnishes, this type of pipe had not proved satisfactory for long service."

Then, in 1955, Missisquoi used 200 feet of 6″ Transite Pipe as part of a new distribution box system.

"During the following year," continues Mr. McGinley, "we watched Transite's performance closely, and were pleased to note that its service was entirely satisfactory. It showed no build-up of stock in lines, resisted acidic conditions satisfactorily, and withstood normal vibrations. Since that time we have installed approximately 1,000 feet of six-, eight-, ten-, and twelve-inch pipes on various stock lines, including discharge from reciprocating pumps, and have been very satisfied with the service received from it."

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APPA-TAPPI RESEARCH FORUM

New York, N. Y., Feb. 26, 1959

Research in the Space Age

LT. GENERAL JAMES M. GAVIN

LAST week a Vanguard weather satellite was placed in orbit, and last week a leading Soviet economist quietly predicted that by 1965 the ruble would become an international currency and begin supplanting the dollar in international trade.

The Vanguard missile was a response on our part to a long and overt struggle in the realm of space. The statement of the Soviet economist followed a series of economic challenges in both word and act which the U.S.S.R. has leveled at the United States and our economy—of which you represent a large and vital portion. In my few minutes I would like to talk about this economic and space war we are now engaged in, and the primary means by which we can fight it. This, I believe, is the fullest use of our science and technology: economy and technology are key elements of strategy in any sound plan for survival today. You, as representatives of a large part of our economy, are a significant factor in the outcome of our nation's dual struggle—and the implications of this struggle are vital to you.

To win the economic contest in the world, the United States must, of course, maintain economic health and growth—and I would like to begin by pointing out the very intimate and inextricable relationship between our technological development and our national economic health. Let me set the stage by reviewing what has happened in the rockets and missiles industry. The connection with your own industry may be closer than it would seem at first glance.

Just about a year ago, when we were well into our recent recession there was much speculation about the causes of the recession. Certainly we had the production capacity, people had money and inventories were high, but people simply were not buying, especially hard goods. We seemed to have everything but confidence. There were many contributing causes to the recession—far too many to discuss here—so I would like to touch upon but one of them, lack of public confidence.

About a year ago I watched a television program on which the West German Minister of Defense, Mr. Strauss, met a panel of newspapermen. In view of Mr. Strauss' background and position as an outside observer, he was asked to comment on the then current recession in the United States, Well, he said, it seemed strange to him that Americans, with such an abundance of goods and money and industrial capacity, were, in fact, having a recession. Furthermore, since he was not an American, he hesitated to comment on our problem, but one thing did seem clear. There was a lack of public confidence, a lack of confidence in our economy and our immediate business future. We possessed all of the ingredients of a health economy excepting one—confidence in ourselves and in our economy.

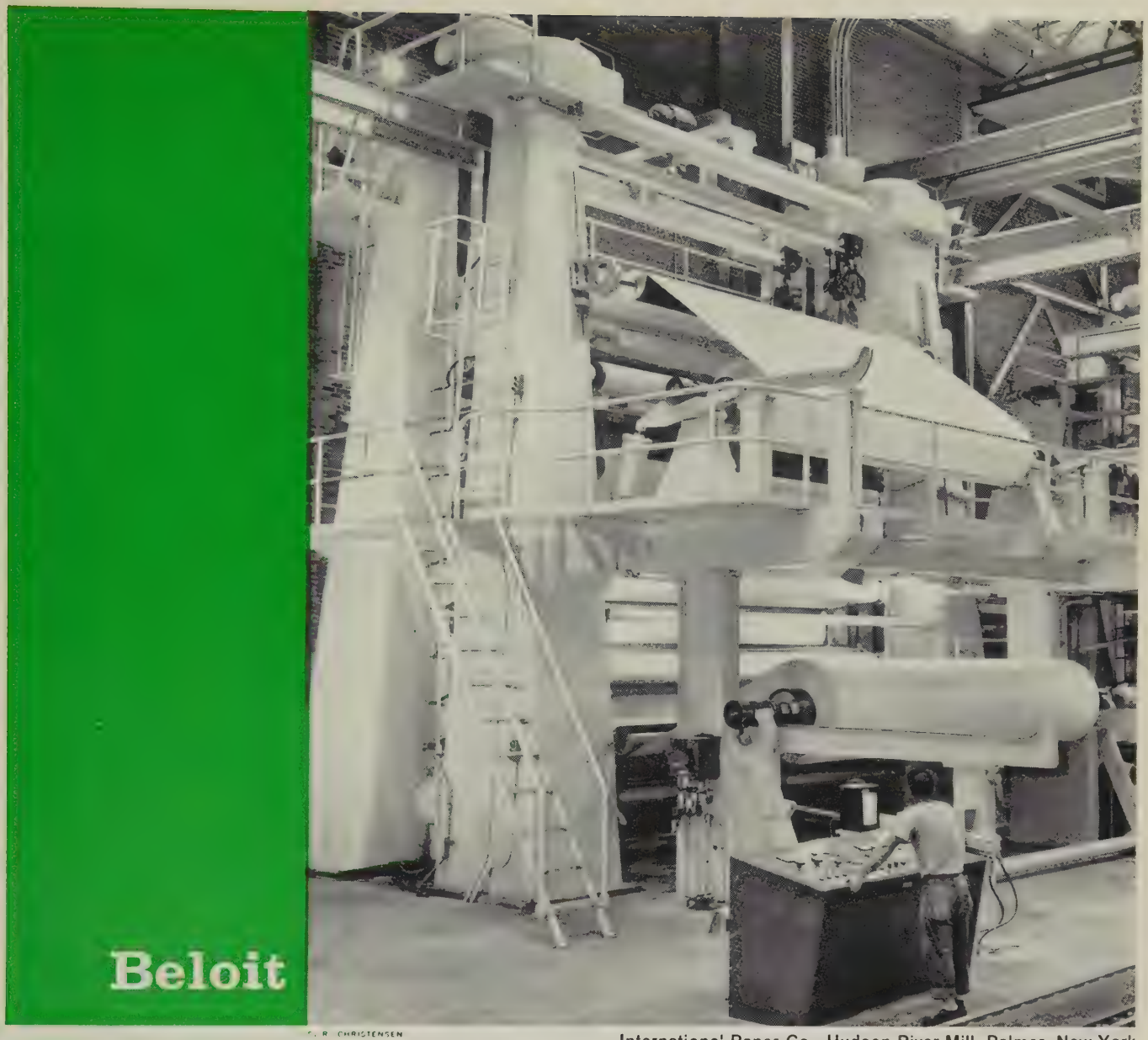
I felt, at the time, that he had singled out the most critical factor contributing to the recession.

On Oct. 4, 1957, the Soviets launched the earth's first man-made satellite. Everyone here remembers the national and world reaction. At home, questions were asked about the state of our education, science, technology, industry, and defense. Whether our decision-making processes in Washington were obsolete, our funding of missile and space programs adequate, and our Department of Defense structure outdated—all became matters of congressional investigation. Public confidence was badly shaken, in spite of the assurance that all was not as bad as it appeared. Until the first United States satellite orbited the earth there was considerable public misgiving about the state of our science and technology. Since Explorer I there have been a number of successful launchings, the most remarkable being the first generation communications satellite, launched in December of last year. Public confidence in our technical abilities improved rapidly. At the same time a similar phenomenon occurred in the economic realm, and the recession now seems to be fading into history.

I realize that "confidence" is an elusive and intangible factor with which to deal—especially in relation to business and industry. Nevertheless, I do feel that the experience we have been through has been a regenerative one. As science and industry have responded successfully to the challenge of the space age, public confidence has improved; and, as confidence has improved, the state of our economy, business, and industry have improved. Industry and science, through their combined contribution to our missile and space program have, in significant measure, restored public confidence and this, in turn, has energized our dynamic and fast growing economy.

It is well that our economic prospects are improving, and not for the sake of improvement, itself. For we are in an economic war with the U.S.S.R. Now the war was not one of our choosing, although we welcome the challenge for what it is. Some time ago Mr. Khruschev

LIEUTENANT GENERAL JAMES M. GAVIN, U.S.A. (Ret.), Vice President and Director, Arthur D. Little, Inc., Boston, Mass.



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stated, "I declare war on you, forgive the expression, in the realm of trade." That he has made up his mind about the outcome of such a war he has also made clear on numerous occasions, perhaps the best remembered being his pronouncement, "We will bury you." Since the issuance of those statements, the Soviets have published to the world their new economic 7-year plan, one of the most impressive documents of our time.

In it, they express the intention of increasing their production 80%. Already, in the first quarter of last year, the combined Sino-Soviet Bloc produced more steel than did the United States. Already, Russian oil exports have begun squeezing world markets, and Russian oil has been shipped in quantity to almost every country in Europe, to Egypt and several other Middle Eastern countries, to the Far East and to South America—at prices beneath western prices. Russian equipment is going to many countries, and Russian cars soon will be appearing in West Germany. Since Khruschev's announcement that wood-pulp production must be upped 130%, it is clear that the Sino-Soviet Bloc is convinced of the importance of paper in the economic offensive now gathering momentum.

Hand-in-hand with this, their technological—shall we say military—offensive is also moving apace. Since their first impressive launching of Sputnik I, their missile and space programs have moved ahead aggressively with the expressed object of developing a family of missiles to neutralize our own military effectiveness and to lead the world in the exploration of space. The competition in the two theaters of strategy, economy and space, is clearly an intense one.

A moment ago I spoke to you about the importance and regenerative effect of confidence on a dynamic growing economy. I believe this view to be valid, while recognizing that there is a more substantive relationship between our economy and our missile and space program than confidence. I believe that it lies in the broad application of missile and space technology to all facets of our economy.

We are, today, in the missile and space industry where the aircraft industry was about 40 years ago. The first thoughts on the uses of the airplane concerned its possible military employment. Few foresaw its great commercial potential. But more important than this, very few foresaw the impact that air travel, the aircraft industry, and its associated technology would have upon every facet of our daily lives and upon our economy.

Not so long ago it was obscure what role atomic energy would play in peacetime. I remember attending a nuclear test in the Eniwetok area with several leading physicists—on Operation Greenhouse. In the course of our discussion, over several days in the test area, many questions arose about the possible commercial applications of knowledge coming from fission. After much talk, it was agreed that, fundamentally it was an explosive of obvious military utility, and little could be foreseen of commercial value. Last year I had dinner with one of those scientists, and looking back, we agreed that the commercial applications of fission and possibly fusion, far exceeded anything we had anticipated.

The scientist with whom I was dining asked, "What are the potential commercial applications of our missile and space technology?" Although it was only a year ago, we could think of very few. Since then much development has gone on. Missile and space technology has become, I think, one of the most significant economic entities of our time.

Already there are so many applications of this technology to industrial and commercial use that I can cite only a few to illustrate what I mean in stating that the missile-space technology has made a large contribution to the economy. The obvious examples have to do with the development of materials for use under extreme temperature ranges. A temperature spectrum ranging from close to absolute zero in the cryogenics area, to those extremely high in the pyrogenics area has posed challenges to our metallurgists and workers in plastics and fibers from which are coming materials of widespread uses. One of the most interesting of the direct applications of missile technology is in mining and oil drilling. The Soviets are making extensive use of jet drilling today, and we have been experimenting and working in this direction for 10 years. We are now extracting the formerly unmineable taconite ores of the Mesabi range by flame drilling. The potential usefulness of this technique is widespread and probably will enable us to pierce the earth far deeper than we have been able to do so far, in search of new sources of ore and hydrocarbons. Of course, there are the obvious uses of missile technology—such as high priority cargo transfer —which probably will be here sooner than most people anticipate. Time is too limited, however, for me to extend this list.

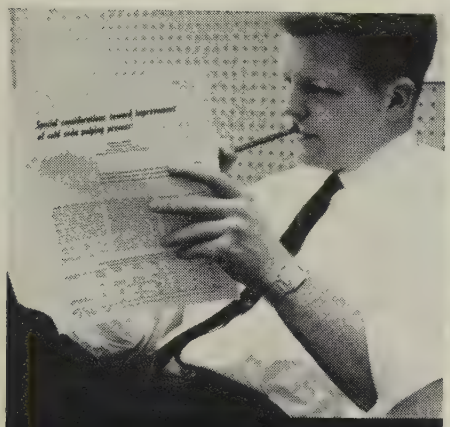
The point is this: our missile and space technology is presently making a direct and significant contribution to our economy. Whenever we add a new source of power, or an efficient method of extracting natural resources—we effectively strengthen our economy for its costly contest in space and in the world market place. In this contest all of our industry, and all of our technical development, is important. For our strength in the contest we need the contribution of every part of our economy.

Let me now turn to the question: where do the pulp and paper industries fit into this picture of economic and space strategy? How do they relate to space technology?

It seems highly unlikely that we will ever see a paper moon, no matter what the song says, and it seems unlikely that cellulose fibers will come into structural use in satellites or space-ships. However, paper does play an indispensable supportive role. We could not do without it for packaging, or for information transmission. Indeed, I am reminded that it can be important in most improbable ways. I remember, several years ago placing a piece of paper inside the nose cone of the first missile to pierce the edge of our atmosphere and return. I am happy to report that the paper returned—not even scorched.

Paper is taking a new role in our changing economy. Even the word "paper" has changed in meaning. Formerly, it denoted only cellulose fibers. Today paper contains glass, quartz, synthetics, and metals. At one time the expression "paper walls" was an expression of scorn in this country for walls which were thin although probably not made of paper. Today, cardboard partitions are ideal for interiors. Again, cardboard shoes, paper houses once did connote the insubstantial—I need not belabor the meaning behind this linguistic

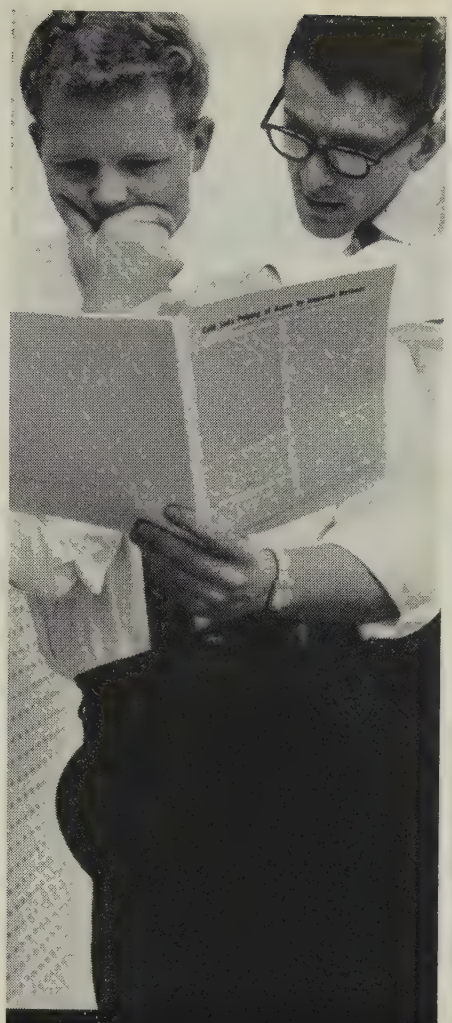
TWO BULLETINS FROM HOOKER ON COLD SODA PULPING



Special Considerations toward Improvement of Cold Soda Pulping Process. This recent paper gives results from experimental and practical work with southern red oak, white oak, soft maple, elm, ash, and yellow birch pulps.

The work was directed toward ways to improve the quality of paper and boards made from these various hardwoods. Charts and tables summarize data on such liquor absorption factors as pressure, vacuum, particle size, moisture content, surfactants, and presteaming.

This bulletin is a reprint of a paper prepared by Kenton J. Brown, chemical engineer of the Forest Products Laboratory, Forest Service, U. S. Department of Agriculture. Circle 252 on the coupon for a copy.



Cold Soda Pulping of Aspen by Improved Methods describes the results of work done under Hooker sponsorship at the Forest Products Laboratories. It describes a practical process for developing corrugating board and news-type papers from cold steeped aspen pulp. The resulting board shows higher strength properties than four other boards made from commercial neutral sulfite semi-chemical pulp. The paper showed itself suitable in every way for magazine-type book papers. The bulletin discusses the process and its results in detail. Circle 250 on the coupon for a copy.

NEW BULLETIN ON BLEACHING KRAFT PULPS

Three-Stage Bleaching of Kraft Pulps to High Brightness describes a new process for bleaching kraft pulp to 85 to 87 brightness with excellent strength retention and moderate color reversion. The process involves the inclusion of a small amount of chlorine dioxide in the chlorination stage and hypochlorite with the caustic soda in the extraction stage. The process requires minimum capital investment. For a copy of this paper, circle 223 on the coupon.

Bulletins like these are made available by Hooker as part of a continuing effort to be of service and to keep you abreast of important developments in pulp and paper technology.

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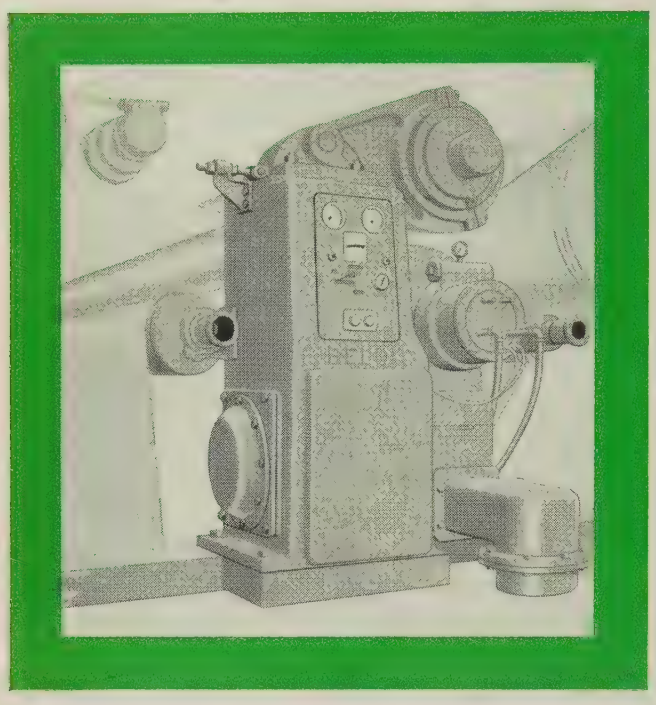

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change. I need not belabor the fact that the uses and volume markets for paper products have changed immensely since World War II, and they probably will change even more in the space age.

This change has come about and is corresponding to a change in our economy and way of life—witness the rise in our standard of living and our gross national product since the war. The paper industry has been a barometer of the rising living standards and economic expansion. Now let me emphasize that the main source of this national economic growth has been research, and take a glance at the paper and pulp industry in the research picture. Where does pulp and paper fit in?

By the end of the Fifties the government and private R&D expenditures will have amounted to $60 billion. In the Sixties the United States will spend easily twice that sum. In the words of *Fortune:* "This is the exponential growth in precisely that area of human activity that exerts the greatest impact on the economy and society as a whole." Last month *Fortune* published a chart of some of our important scientific and technological accomplishments in the Fifties. Some are already important to the economy. Others will be soon. Among the listed achievements were: electric power from the atom; coast to coast TV; computers, and industrial automation; synthetic fibers: orlon, dacron; polyethylenes; transistors; synthesis of insulin, cortisone—tranquilizers; first missile probes, and satellites.

These discoveries and developments gave a boost to the economic, physical, and mental well-being of our nation. The scientific and economic lunge forward benefited the pulp and paper industries, although they were not prominent contributors.

In the Sixties, we will see another lunge forward. In listing a few of the technical achievements forecast for the next decade, I would like to pose again the question: Where does paper fit in? Among the achievements will be; total synthesis of chlorophyll, and possible control of cell growth; thermoelectric power; nuclear-powered aircraft; outer space probes; weather prediction and control; major advances in conquering mental illness, and physical illness, including a cancer cure; major advances in structural metals and other materials; machine translation of languages.

Perhaps, in the late Sixties, nuclear power will be competitive in the United States; and we will have fresh water from the sea, control over animal and plant mutations, and manned space flight.

Now, if many of these come to fruition in the Sixties, life will change again as much as it has changed since the Forties.

The paper industry very closely reflects social change. As our company has found in its area development work, rising standards of living immediately produce increased consumption of paper. Quite probably the rising standard of living at home, and the development of the so-called undeveloped nations will, at least initially, mean a large increase in consumption of certain paper products. This is one of the implications of the technical forecast. It is not a long-range implication.

Research has already had an impact on the pulp and paper industries in the form of competition. Quite probably, unforeseen competitors will continue to arise —competitors such as the metal and plastics industries. For some purposes, new technical advances will require

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the substitution of synthetics for cellulose fibers. This has already happened in the evolution of filter papers. As you remember, filters in World War I gas masks were cellulose, paper in the old sense of the word. World War II produced intensive work on atomic energy and the AEC required filters for submicron particles carrying radiation: the absolute filter developed for the AEC used synthetic fibers.

In other areas, where companies are vigorously pursuing research and development, it is quite possible that they will invade the cellulose markets.

This is, of course, only the domestic side of the picture. A considerable part of the coming change will issue from the dual theater of war that I was mentioning earlier. How will the paper and pulp industries affect, and be affected by the competition for world markets? It is my opinion that the industry will be mightily affected, and can be mightily effective.

You need not make the mistake about Soviet techical abilities that many people did before the launching of the first sputnik. You will remember that the Soviets were quite verbal about their intentions to launch a man-made satellite, and published considerable data about it beforehand—which few people believed. Some time ago the story was recounted in *The New Yorker;* it described how the Russians told us the weights of their satellite-to-be. We thought them technically incapable of putting such a sputnik into orbit, and decided that there must have been an error in calculation or at least an error in translating the measurements for an English-speaking audience. It was then, and is now, high time for everybody to erase the old image of the Soviet peasant in a babushka. The Soviets' technical strength is great, and not only in the realm of missiles and space. They are proving themselves technically able in many other areas—and cannot be dismissed. Before the launching of sputnik many people said that the Russians lacked know-how. Today some people will acknowledge their know-how with respect to rockets and missiles, while proclaiming them sterile with respect to the many other areas of a large technology. This, too, is a mistake, as the Russians are proving in their economic assault on the free world.

In the past three years, the Russians have been demonstrating that they can, by fiat, focus their efforts on any problem they choose—and undersell us in the world markets. Last fall, in speaking to the Conference of AMA presidents, I mentioned this point, and a gentleman came up to me afterward, and said that I had not been emphatic enough. He told me, that in South America where he had been selling pulp at $120 a ton, the Russians had come in and undercut him by selling pulp at $80 a ton. Recently, West Germany has been getting pulpwood from behind the Iron Curtain at prices lower than offered elsewhere.

In its first five-year plan, Red China claims to have planted about 28 million acres of forests, and plans to double her forest area in ten years. As this month's *Cellu-Letter* comments: "Clearly she recognizes the dynamic economic power of wood cellulose in the world trade struggle." There is every indication that the Soviets intend to try and capture this dynamic power for their own. Toward the end of 1958, Sweden and Russia signed a 3-year trade agreement, indicating that Sweden will send the Soviet Union about 225 million kroner in goods this year—primarily in equipment for the pulp-paper and mining industries. Meanwhile, Khruschev has announced that Russian production of newsprint is to be raised 80%. He plans production of pulp at 130% above last year.

For some time, the Russians have been working in processing for paper production. Recently, a visitor abroad reported stopping in Sweden, where he saw a sample of very fine paper that was made by a dry-formed process. It had come from the papermaking school in Leningrad. As I understand this, it could mean a revolution in the papermaking process. In our production of high grade papers, we use about 40,000 gal. of water per ton of pulp—and the handling of water, the draining, and drying of the wet process constitutes the major expense in our present manufacture. The dry-form process eliminates this major expense. Dry pulp is used. In this country the dry-form process has been used in a limited way. Particles mixed with synthetic resins are blown in a stream onto rollers, pressed, and baked into bond. So far we have only produced rough, low density board by this process. If high grade papers can be produced by this kind of method, a startling advance will have been achieved.

It is clear that research, abroad and at home, will be the major influence on the pulp and paper industries in the space age.

It is by research that the industry will assume its important role. Investment in creative research is, indeed, the only means by which the paper industry will find new markets and products in anticipation of its competitors—and reap the kinds of benefits that the chemical and pharmaceutical industries enjoy. There, investment in basic, long-term scientific investigation is paying off at the rate of about one new drug a week.

The precedent for this aggressive research can be seen in World War II, when we were forced to adapt paper to new uses. Paper substituted for many materials then in short supply; and out of the research of the time, new products were born. In World War II, wood cases were replaced by corrugated containers, metal drums by fiber drums, textile bags by multiwall sacks, lumber by wallboard, light metals by paper-base laminates. Paper was substituted for metal foil, glass, silk, leather, hemp, ceramics, rubbers, plastics, cork, mica, straw, plaster, etc., and I can add, from my experience in the field, that paper was an appreciated pinch-hitter.

In the space age, the vital role of paper will come from a similar research effort. The tree is, after all, one of our few replenishable resources. Although paper may not be used to construct satellites or space ships, it is probable that we will need to call upon paper to pinch hit again—to relieve high-priority metals for space ship construction and so forth. Wood could conceivably serve as the raw material for rocket fuels. It is conceivable that the increased use of electronic data processing will free tons of what is now office and book paper for use in the construction of building interiors, laminates for electrical parts, etc. Just this month, *Dun's Review*, published a note on a new thermoplastic kraft paper with many possible uses aside from packaging, as in instrument panels, door panels for cars, and even toe and heel structural parts for shoes. The versatile potentialities of paper in support of our long-range space program will come about through the scientific investiga-

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tion of every possible function. Just as missile technology can strengthen the national economy by applications to civilian needs, so your research can contribute greatly to the industry and national economy. It is no news that research pays good dividends—a research investment yields up to 200% over 25 years. Already there are many interesting research results to see in the pulp and paper industry's trend toward new processing methods, in the use of automatic control, semichemical processing, and the greater processing speeds possible with new methods.

I have been interested in these developments, and in the new developments in packaging—and in the mergers of lumber and paper companies, and mergers of paper with chemical companies. We are all familiar with the benefits from the increased use of chemical by-products of the pulping processes.

In all of these developments the paper industries are benefiting from technical progress in numerous fields. To utilize the potentialities of the accelerating technical progress we are seeing, it is evident that industry must invest in a long-sighted effort of scientific investigation. Only deliberate research and development will produce results with a significant future.

In this direction, I have been interested to learn of the operational creativity group on which my company has worked with Kimberly-Clark. The Kimberly-Clark group under Bill Wilson has been established with the goal of stimulating creative ideas, and probing them. Its goal is the encouragement of imaginative ideas, which, in our age, are the crucial elements in productive research. The establishment of this group was a courageous step. However, as we have witnessed in the Bell Telephone Co., it is by the acknowledgment and nurture of imagination that the future is anticipated. Furthermore, I repeat—we are at war, and research is one of our most potent weapons.

The strength of the pulp and paper industry in our nation's war of technology and economic achievement will depend a good deal on imagination, on how well the industry keeps up with the pace of technology—how flexible it is—whether it anticipates change. The answer, by the end of the 1960's, will depend upon whether your thinking and research ends with the cultivation of present demands, the expansion of present markets—or whether you have surveyed the social and economic changes to come in the space—or research age.

Presented at the APPA-TAPPI Research Forum held in New York, N. Y., Feb. 26, 1959.

What Research Expects of Top Management

HOWARD S. TURNER

More than once, as I prepared my talk for today, I kept wondering why it should take me 25 min. to tell you about the one thing that research expects of top management—and that's MONEY!

However, I am forced to admit that there are other considerations which are important—in addition to money. The president of my company, Avery C. Adams, and I have had many discussions dealing with productive top management-research relationships long before I was honored by the invitation to speak to you today. Consequently, he has taken a special interest in this assignment and, at the outset, I want to acknowledge his helpful and constructive advice.

Understandably, when we think of this top management-research relationship, we are concerning ourselves primarily with matters of policy. And I think it can be demonstrated that management may expect a return on its research dollar just to the extent that it has formulated statements of policy governing research in the corporate scheme of things, and has gained acceptance for those policies by all members of the management team.

Furthermore, the implementation of those policies will require, on the part of top management, the development of a useful understanding of research people, of the research function, and of the concept of research as a working partner in the job of turning a profit for the shareholder.

This all sounds rather general, but it is not hard to become quite specific. First, with respect to an over-all policy—unless the desire to lead his competitors in one or more important respects is foremost in the president's mind, be should be excused from worrying about research at all. He will need some quality control work, but that is not research. He may well need some research to cut costs, but you might say that is just the result of competitive pressures. In short, if a company president talks mainly about getting his share of the market and not about scheming to take somebody else's share, or creating a new market, he is a commercial gentleman, but wrongly cast as a supporter of industrial research.

Fortunately, a lot of company presidents do have that kind of drive—that's why they are presidents! They recognize and accept the risks inherent in the execution of such a policy. But I am not so sure they always know how best to use the capabilities of research as their ICBM, or how to minimize the risk factors in their financial backing of research.

So, basic policy in the research area starts with the recognition of research as a powerful tool that can win competitive advantage, and with a concurrent company-wide conviction that this tool *will be used* for its maximum effectiveness. This leads naturally into establishing an atmosphere that requires accountability to the president, by all management people, for the most thorough efforts to make maximum use of new technology in every phase of the company activity—obviously in new plant investment, but also in maintenance, replacement, and in the sales area as well.

But it is pretty hard to go about applying technology or even creating it unless company targets represent

Howard S. Turner, Vice-President, Research and Development, Jones & Laughlin Steel Corp.

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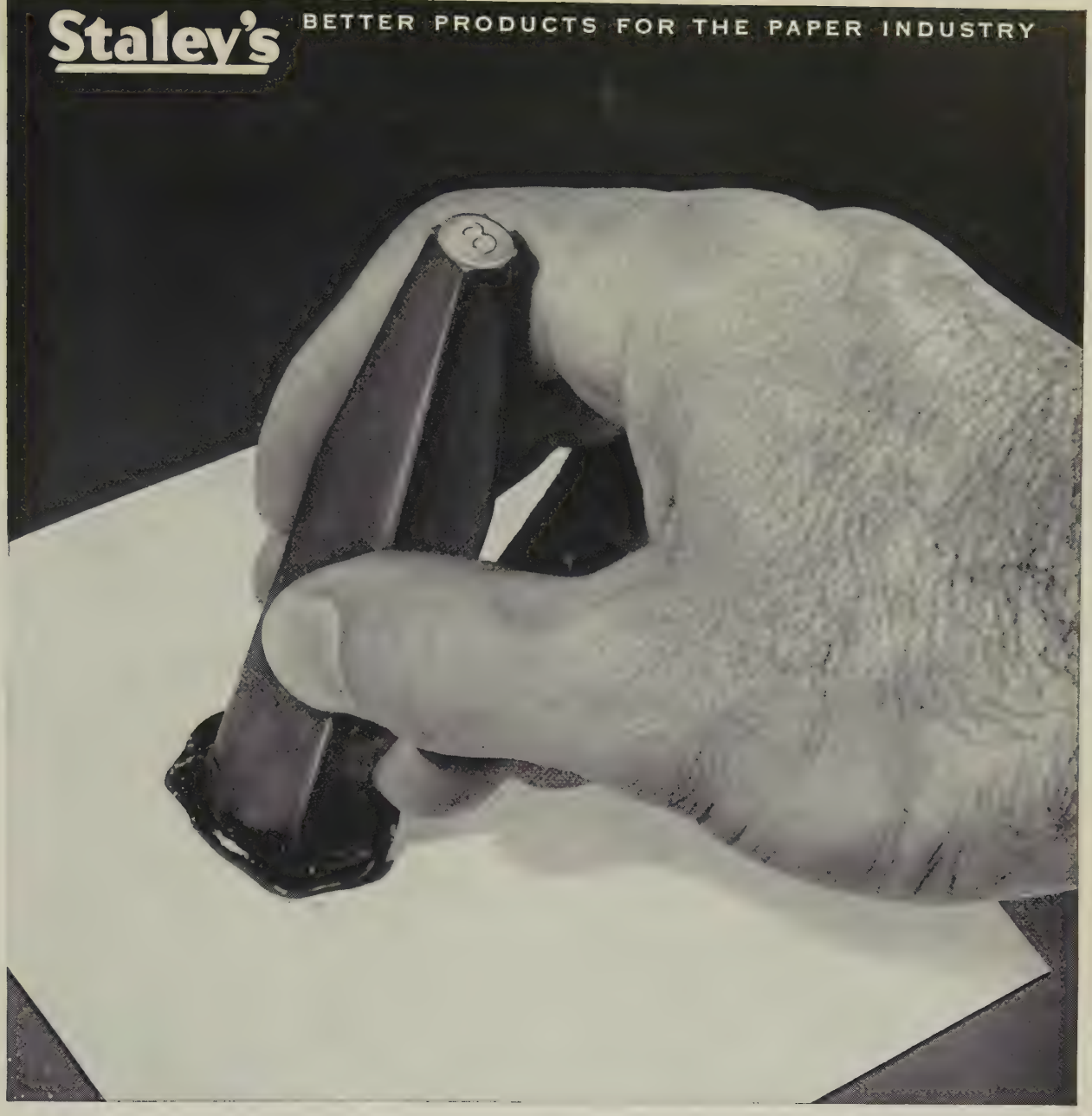

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more than a mere homicidal attitude toward competitors. Developing these targets is not the simple mental exercise which some of our management consultant friends suggest in the flood of papers about corporate objectives and long-range planning. It is a very tough job. But lack of targets and plans introduces the greatest single risk of unproductive research; that is, some morning an egg is hatched at the laboratory after a long and expensive effort, and then to everyone's consternation the resulting bird is about as popular in the general office as a mouse at a ladies' teaparty.

Now, while these broad policies are being formulated, where in the organization chart does one go to find the top research man? If he is not a member of the management team assigned to hammer out these policies, more risk is added to the research investment. So, it seems obvious that the top research man must be a member of the management team, sharing the same perch with the top officers in charge of production, sales, finance, etc. Then the president will beel the same obligation to keep his top research officer informed as he feels toward his other officers—informed of all matters that will strengthen that officer's ability to contribute toward targets that have been jointly derived.

These targets are frequently born of a group effort—perhaps the recommendations of a long-range planning committee checked against the views of the president. Obviously, from the nature of his corporate assignment, the research officer should be a working member of such a group. Until these targets are set, and the part to be played by new technology in reaching them is defined, no one can make an intelligent appraisal of how big the current and future research effort of the company should be. It becomes either a fat cat vulnerable to a swift change in diet, or the alley variety unequal to the sudden demands of combat.

The research head has no right to expect top management to formulate all these plans and objectives out of thin air and serve them up under glass. He must be made, by the president, to feel an obligation to make creative contributions himself. In extending this invitation, top management reduces the risks of misdirected research and convinces the whole research organization of its essential part and responsibility in the corporate plan of things.

Before leaving some of these broad policy questions, I would like to say a word about patents and the part they play in the top management attitudes under discussion.

Some company presidents may entertain doubts about the expense of a vigorous patent policy. But support of such a policy, to get all the law allows in a constitutionally authorized monopoly, is fully consistent with gaining the most from our research investment. Unless the company president is unconcerned about wasting company assets—which is *very* unlikely—he should have a positive and forceful policy on securing maximum patent protection for the products of his research laboratory. Administration of such a broad policy has the very practical effect of encouraging invention, which is the foundation of a productive research organization.

Research is a high labor item, with salaries frequently over 70% of the total budget. This fact alone urges upon the president the importance of understanding research people. Some unknown Quaker said, "Everyone is a little queer except thee and me, and sometimes I wonder about thee." Whether or not they are queer, research people as a group are different, and very fortunately so. Their being different stems from a characteristic individualism, which in turn is part and parcel of the way a research man makes his professional contribution. For all the talk about team effort as the modern tactic of technical investigation, progress, in the last analysis, comes only when some individual has an idea. Two people can, and often do, come up simultaneously with similar or closely-related ideas, but progress in research remains a highly individualistic mechanism.

All of us, including company presidents, feel more comfortable with people who are not "different"—that is perfectly natural. Presidents particularly, however, should recognize why many good research people are "different" and join with the Frenchman who for quite different reasons said, "Vive la différence"!

Consistent with this individuality, it should not be surprising to the president if his research organization operates best when it is not too highly structured, and when internal relations are informal and easy. For the larger laboratories particularly, maintaining this kind of atmosphere takes an especially conscious effort.

A personalized approach to recruiting pays off. This is especially true in the existing imbalance between the demand and supply of good technical people. Some of the older hands in a company naturally may resent what to them seems like babying young graduates. But if the original "soft-sell" is presented with a friendly challenge that the young man is being offered the chance to run with some fast competitors, he will see this opportunity in its proper perspective.

A policy of individual consideration also takes cognizance of salaries. There are salary administrators who hold the idea that researchers can be herded under the same tent of salary rules that are in effect elsewhere in the company. This is as dangerous as it is fallacious. A well-trained, high-quality physicist or chemical engineer uses the same tools to solve problems for a company beneficiating copper ore as he does for a paper company. He is a "citizen of the world" in an industrial sense, and the salary patterns applying to him should recognize this "common currency" of the technical man. No industry should complain that it does not get and retain its share of technical men if it has imposed the heavily-stratified salary structures of its nontechnical employees on the scientists and engineers of its research laboratories.

In short, research expects of top management a recognition of the individuality of the research man on the very practical grounds that policies fostering that individuality will pay off in research productivity.

The president also has a responsibility for building the confidence of his top research officer. This is no problem at all in companies where most of the policies I have discussed are deeply rooted in corporate practice; but in companies where these policies are not so rooted, the suspicion that the president does not fully understand research or research people may not be easily allayed. Obviously, the research officer himself has major responsibilities in building this relationship with the president. But the recent emergence of research as

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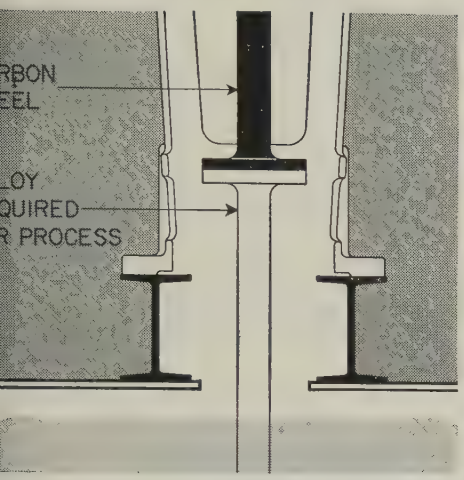

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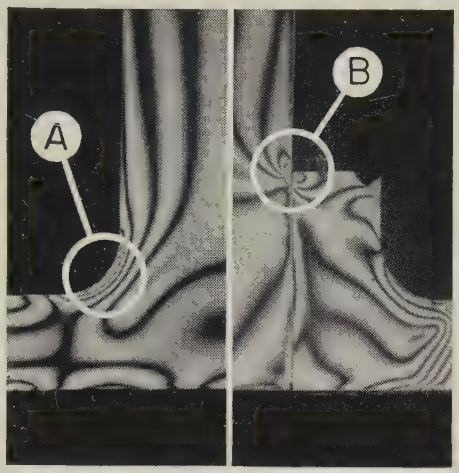

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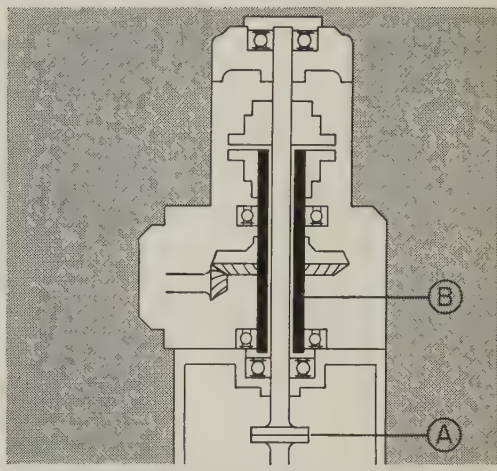
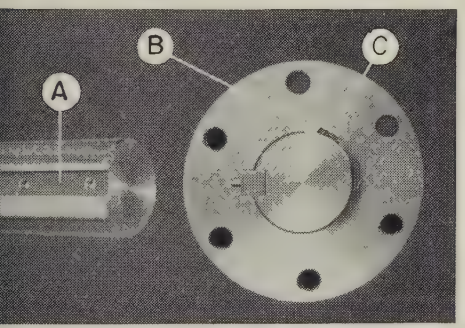


3. No need to disturb gearing if you ever want to replace a LIGHTNIN shaft. Lower shaft is unbolted at (A). Upper shaft slides out of hollow reducer quill* (B). Gears remain untouched—cannot get out of line. When new shaft is installed, shaft alignment is automatic. *Patented



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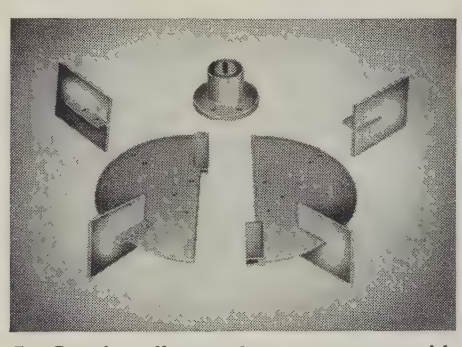

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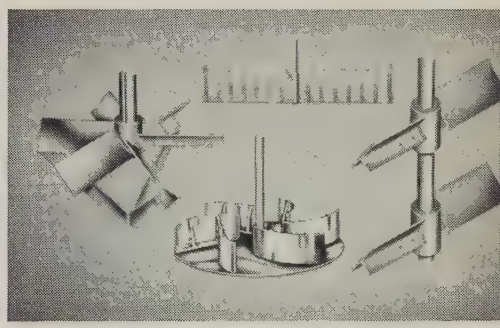

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a member of corporate management suggests that the president will find it desirable, and productive, if he takes the initiative.

The president will wish to give special recognition to encouraging practices that motivate his research people in a developing sense of loyalty to the company. I have about concluded that no one likes to see his name in print more than a researcher—in the right places of course. These people are strongly responsive to professional prestige as expressed by freedom to publish results, and to attend and present papers at technical meetings. The president should recognize that a liberal policy in this respect does pay dividends.

But the most productive act the president could perform to foster company loyalty, and research productivity as well, comes about as he demonstrates to his researchers that he is personally anxious to see the results of their labors put to use. This may seem crudely obvious, but more presidents should appreciate the beneficial effect of this personalized interest in the progress and application of selected research projects. The researcher likes to think that the president is holding other departments accountable for *extracting* and *using* information developed by research, as well as holding the research group responsible for producing it. To a scientist who has chosen the industrial laboratory for his place of work, there is no reward so great as the feeling that the fruits of his labors are wanted; or seeing the results of his labors placed in actual use. A president anxious to get the most for his research dollar should give top priority to establishing this atmosphere.

Assuming that these remarks help the president to understand his research people, what of the research function itself? Top management should educate itself to be able to talk research objectives, and to review research progress, with a feel for the procedures involved. It is the responsibility of the research director to develop a means of communicating with his president, but the president must accept the job of learning how the researcher conducts his business.

A friend of mine in another business once said of his management—"We only do the obvious." This is a pretty safe and often profitable policy when the executive is surrounded by a variety of known situations and relationships. But if the president finds such an orderly procedure in his research laboratory, he quite possibly is looking at a very sterile investment. The researcher is hired to invent and to solve problems but quite literally "unobvious" methods. In fact, the U. S. Government Patent Office is very abrupt in its dismissal of patent applications which to that Office seem "obvious."

Hence the selection and execution of research projects may not follow obvious procedures. Ideally, all projects should have been evaluated for potential success and weighed for financial return. But if these answers were always obvious at that point, the problems were not for research.

As a matter of fact, substantial areas of research activity are not orderly or efficient in the conventional sense, since this degree of superficial disorder is necessarily characteristic of a system that is charged with defining and solving problems by the derivation of new scientific principles and technology.

Some have said that as a consequence research is just the throw of the dice, a pure gamble. Were the process truly random, one would have to assume that we were also drawing quite randomly on our inventory of scientific facts in solving our problems. Of course this is not so. The distinctive contribution of our best scientists has been the selective organization of scientific facts to provide tools for our technologists. In other words, the dice are loaded.

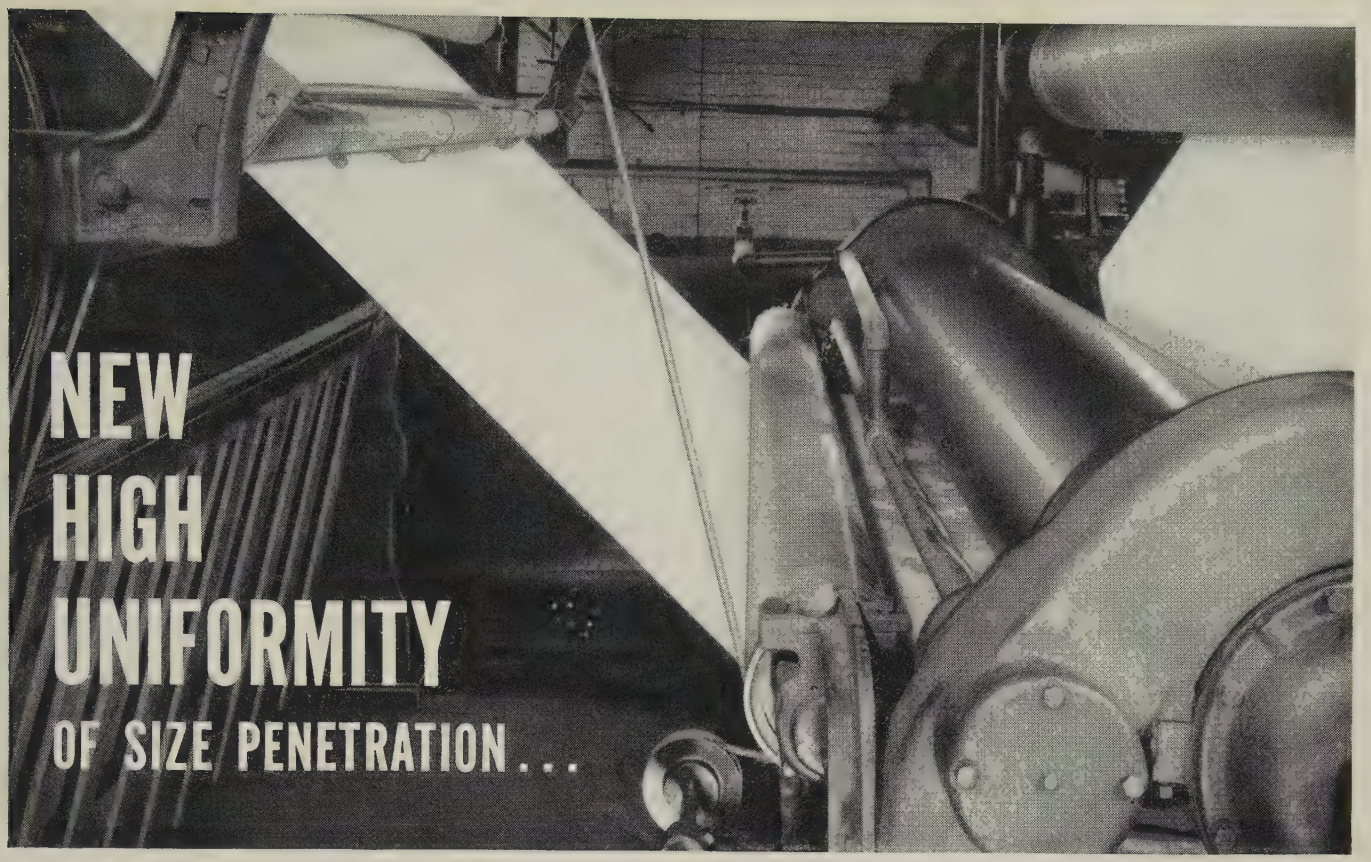
Furthermore, research need not be so irresponsible as to approach its problems on a pure-trial-and-error basis. The modern researcher operates according to a plan—we call it "experiment design." A series of experiments is preselected to isolate suspected variables, reveal their interaction, and lead to definitive results. This quality of research the president has every right to expect.

Even so, the president may be appalled at the prevalence of failure among research investigations. But he must learn to differentiate between the failure of intermediate projects and failure to achieve the end objective. Failure can be a hallmark of a very aggressive and productive research organization for the simple reason that failure of a project or an experiment in a well-managed research organization provides the evidence that frontiers are being attacked. Kettering said that one measure of a good researcher is his ability to fail successfully—to capitalize fully on the knowledge gained in his failures. Therefore, a properly-planned experimental program should be expected to experience many failures along the way. This is a characteristic of good research that must be understood by top management. Don't put the research director on the defensive so that he hesitates to report failures—rather, press him for the way he proposes to use what he learned.

Understanding research people helps one to understand the research function; and understanding both helps the president to provide ultimate leadership and valuable constructive criticism, while assuring maximum productivity for the research dollar.

What should research expect of top management in the way of evaluating research results? On all sides one hears speakers attesting to the existence of some precise way to measure the returns from research. Among the top managements of companies with long histories of well-managed research, these platform pundits merely evoke patient smiles, since this concern about a measured return on research alone merely reveals an immaturity in integrating the concept of research into the corporate structure. Research has no value of itself; its results are absolutely worthless, just so many nicely-bound reports, unless these data are given form and substance in operating investment, and in customers found for the new or improved products. While research starts the train moving, there is no cash in the drawer until the company, operating as a whole, has brought all of its components to bear and the customer has played his role. How arbitrary to select one component of the train in assigning the credit, or in fact any fraction of the credit, derived according to some highly-subjective formula!

On the other hand, a carefully-thought-out policy statement will highlight the responsibility assigned to research for producing technology. If the company fails to meet corporate objectives toward which research has agreed to contribute technology, the president does not need an arithmetical formula to evaluate his re-



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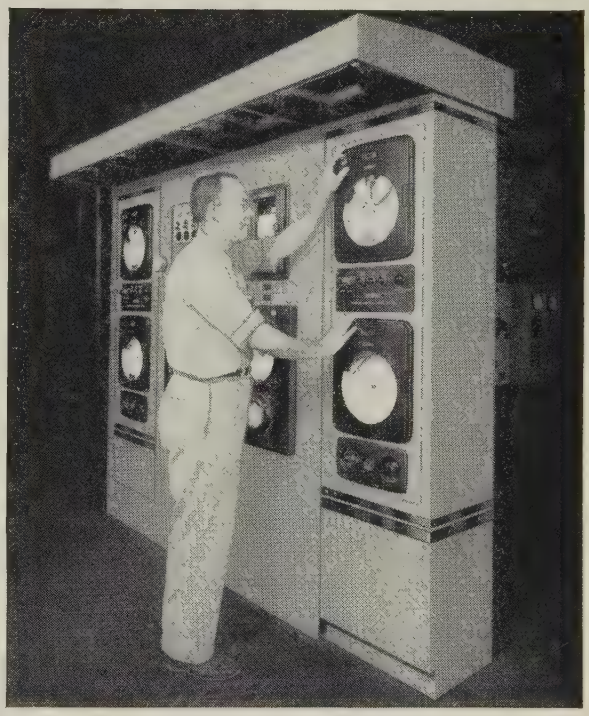

"Our quality standards are more easily maintained," reports West Virginia Pulp and Paper Company as a result of this Foxboro Moisture Control System. Cabinet shown here contains Dynalog Electronic Moisture Controller (top) and Temperature Controller (bottom).

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AUTOMATIC SHEET MOISTURE CONTROL

search organization. As Duer Reeves of Esso has pointed out, the job of industrial research is to produce technology when it is needed. If produced too soon, it becomes obsolete; if produced too late, the company suffers competitively. If top management thinks out its goals, and understands the contribution that research-generated technology can make to those goals, then research can expect understanding criticism and proper evaluation of its performance.

In summary, research expects the following things from top management:

1. Membership on the management team, with all that membership implies in the opportunity to take part in and the obligation to contribute to the formulation of policies and corporate targets.

2. A corporate policy that obliges all members of the management team to maximize the application of new technology in all phases of the corporation's activity.

3. An understanding of research people and the process of research so as to encourage productivity and build a soundly-based loyalty of research people to corporate objectives.

4. A practical concept for the evaluation of research in which the research organization is viewed as another production unit in the company, with obligations to produce the technology on which the current strength and future growth of the company are based.

I don't intend to take time here today to score J&L against these standards, but I can say that our top management fully supports the views I have expressed.

But in any company, when all these goals are reached, the president and the research director will have only one further subject of conversation—and that is MONEY!

Presented at the APPA-TAPPI Research Forum held in New York, N. Y., Feb. 26, 1959.

What Management Expects of Research and Members of Its Research Staff

A. B. LAYTON

The other speakers this afternoon are discussing research from the viewpoint of its importance and what the researcher expects of management.

I would like to discuss some aspects of research from the viewpoint of what management of the average industrial corporation expects of research and the researcher and also talk a little about research in the paper industry, with the hope that I may provoke further thinking and discussions of these subjects on your part.

First of all, what management calls "research" may be quite different from research as it is regarded by scientists and technical personnel. It has been my observation that the definition of research by management will vary by industry, company, and the purpose for which research is being defined. For example, in addition to fundamental and applied scientific research, some managements will consider as part of their research effort such things as market research, economic research, long-range planning, technical or process control, packaging design and development, engineering, mechanical development, capital expenditures for laboratories and other facilities, memberships in and contributions to technical and scientific associations and institutions, and fees paid for technical and research services of various sorts performed by outside agencies.

It is not my intent to discuss which of such items properly should be classified as research but merely make the point that managements of various companies are not unanimous in their thinking as to what constitutes research or their research effort.

This ambiguity is compounded when members of the investment community attempt to evaluate the relative research effort of various companies or industries in terms of annual dollars spent, or in terms of such dollars as a percentage of sales. For not only do the definitions of research vary, the nature of what is included in a company's consolidated dollar sales also varies—particularly in these days of consolidations and diversification. Some sales dollars properly should support scientific research—others marketing and economic research—others engineering or mechanical development research—and other sales dollars, little or no research, depending on the nature of one's business and industry.

Therefore, while dollars spent for research may give you a general idea of the magnitude of the research effort, in my opinion such figures are not a reliable basis for evaluating the relative attitude toward research between companies or industries, or the effectiveness of their respective research programs.

Furthermore, insofar as scientific research is concerned, I have always felt that the *quality* of research performed was a better criterion of a company's research effort than the quantity of research undertaken, the number of scientific personnel on the payroll or the size or appearance of a laboratory.

Therefore, in meetings with investment groups, when I have been asked the question, "How much does your company spend a year for research? or "What percentage of your sales do you spend for research?" I have generally replied, "I would rather not give you such a figure because it would be misleading and might cause you to draw erroneous conclusions in measuring our relative research effort and effectiveness with other companies."

For the balance of my remarks this afternoon, however, I will talk of research in terms of fundamental and applied scientific research as it is generally understood. Another way of putting this is "learning work" and "applying work," in which "learning work" is concerned with the acquistion of knowledge and the understanding of nature, while "applying work" is concerned with the

A. B. Layton, President, Crown Zellerbach Corp., San Francisco, Calif.

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application of this knowledge and understanding to the output of goods and services.

For management to expect results from its research effort and the members of its research staff, it seems to me that it must first establish a policy and climate that fosters research and one in which research may flourish. For example.

1. Management should not regard research as just another form of overhead, to be turned on or off in varying degrees as a water faucet, with fluctuations in the business cycle.

2. The research program established should be a broad and sustained effort for the over-all benefit of the company and not one beamed at limited problems or putting out fires in a given department.

3. If the head of the research function is not a part of top management, the research program should not be set up organization-wise as an adjunct of manufacturing or sales departments, but independent of them and on an equal status, reporting direct to top management.

4. The research effort should be integrated into all the other corporate operations and not set apart as the idea department or ivory tower boys.

5. A comprehensive system of communications and follow-up should be established to make sure the results of research are disseminated and used and not sent to the files.

6. Research personnel should be given opportunities to advance into other positions in the organization if they so desire, rather than have as their ceiling only the jobs that exist in the research effort.

7. Management should establish priorities for the various projects in the research effort rather than expect their research department to do this.

8. Management should not attempt to evaluate the results of research in the same terms of dollars and cents return on investment, or number of years required to pay out as it evaluates expenditures for capital additions.

9. Research personnel should be permitted and encouraged to exchange views with their scientific colleagues and attend and participate in meetings of scientific and technical associations.

10. The research effort should be a sincere one and not one primarily beamed at financial public relations.

Once management has established a proper climate for research, in my opinion, management has the right to expect such things as the following from its research effort and members of its research staff:

1. The realization that in any industrial research department, the objective of the effort is to return a profit —not in a specified number of years as a capital investment, but in a reasonable period. An industrial research department has primarily been created and is sustained to enhance the earning power of the company—this should never be forgotten.

2. A reasonable performance by the research department in the solution of the applied research problems undertaken. No research department should expect to have funds allocated to it indefinitely if they don't deliver.

3. Realization that the average industrial company can only afford to have a limited amount of its research effort devoted to fundamental research. The predominant effort must be in the fields of applied research. True, companies such as Bell Telephone, General Electric, and duPont do spend substantial funds for fundamental research but they are not average industrial companies. I do not mean by this that some fundamental research should not be performed or financed in other institutions. However, in my opinion, any researcher who preliminarily wants to engage in fundamental research should not seek employment in the average industrial company.

4. Loyalty to the company in the applications of their disciplines rather than applying them in fields that are of particular interest to the researcher but not necessarily to his employer.

5. Researchers should not claim or expect to receive all of the credit from the results of their research because, generally, efforts by members of the operating, engineering, and sales departments also contribute to the solution and application of a research project. In Crown Zellerbach, we think of our research department as having "assisted" in the solution of a problem or in creating a new product, rather than give them the full credit.

6. Researchers should realize that in asking for capital appropriations or operating funds, they are competing with all other departments in the company for which dollars are available, and that each department also thinks its own needs are the most important for the well-being of the company. Therefore, they should not feel deflated if their request is turned down or deferred, or their requested appropriation is not granted in full.

7. Research personnel should take their place in a division and community the same as all other company employees in the area and not regard themselves as better or something apart from all the others. This also applies to their wives.

8. Researchers should originate problems and projects as well as work on those received from others. To effectively do this, they must take an interest in and acquaint themselves with the over-all operations, problems, and objectives of the company.

9. Research personnel should not want to undertake every project themselves and resent participating in group research efforts or having projects or parts of projects farmed out to other qualified agencies. I am sure you will agree that one of the biggest wastes of industrial research is duplication of effort.

10. Top research people should actively endeavor to lead top management in formulating the company's research program so that management is cognizant of and understands the direction and development of the industry's technology as well as the technological developments in other industries that may be applicable in the company's affairs.

Now, as to research in the paper industry. In my opinion, our industry has lagged and is today relatively behind in its scientific research effort compared to other basic and growth industries, as well as in relation to the research potential and need for research that exists in the paper industry. However, I think there are logical economic reasons for this.

It is generally recognized that what we today think of as industrial research first came into being around 1920. Prior to then, with a few exceptions, industrial research was primarily performed by geniuses, such as Edison and Steinmetz, who were supplied with laboratories and

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Physical Properties

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Adhesion	Excellent
Particle size	900 Angstroms 0.09 Microns

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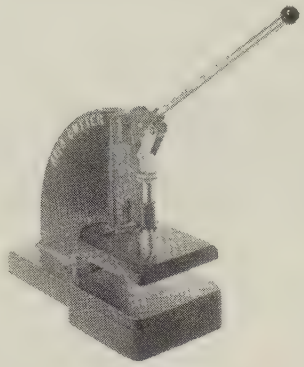

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turned loose. Today's concept—where you take a group of capable scientists, but who are not geniuses, and direct their collective efforts toward the solution of definite problems—really has existed only for the past 40 years. Let's look at the paper industry in this span of years.

By 1920, the industry was established in the United States, using pulping and papermaking processes that had been developed in Europe by the Scandinavians, French, and Germans. The industry substantially expanded in the 20's during which its principal scientific efforts were devoted to establishing technical control of its various processes. For example, some of you will recall the beaterman of this era who could tell much better by feeling with his hand than using instruments whether or not the stock was properly refined and the general resentment of operators to technical control of any sort. Papermaking was an art—not a science.

To me, this suggests that research in our industry has evolved from technical control and explanis why some people still regard technical control as research and many companies have the direction of their research effort under their manufacturing departments.

Following this technical control era and the expansion of the industry in the late 20's, we experienced the depression of the 30's during which, until about 1937, the industry had all it could do to keep its financial head above water, much less spend money for research.

Two notable exceptions during this period were· (1) The Institute of Paper Chemistry established in 1929, and (2) Kimberly-Clark Corp. which, I have been told, sustained its research effort in lieu of paying dividends.

Research in our industry generally began to receive attention about 1937 with the business recovery. I might add, our own Central Research Department came into being about that time although it was then called the Central Technical Department, further illustrating the evolution of research from technical control. The research effort of the industry gradually expanded until the outbreak of World War II when shortage of scientific personnel and materials made it difficult for companies to sustain the research effort they had developed to date, although The Institute of Paper Chemistry did make substantial research contributions to the war effort.

With this background and for these logical reasons, research in our industry really only began to move forward in a substantial degree following conclusion of the war. Therefore, it is only for the past 10 years or so that the industry has really begun to implement its research effort and has had the personnel, materials, and funds to do so.

So, where are we today? We have some reasonable research effort in perhaps 20 out of several hundred companies, but in my opinion, none of us are yet paying the attention to research that we should if the industry is to not only catch up with the research progress made in other industries prior, during and since the war but keep pace with the research effort in the present economy and in the years ahead.

You may say, "We are not in the chemical or electronics business," or, "Our industry is different—our products are mass-produced and there is little absolescence," or, "Our suppliers or machine builders do the research for us." To me, these are not valid reasons for not engaging in research but excuses. In this day and age, our industry must undertake more and more research with ever increasing diligence if it is to compete with other industries and continue to grow.

Although as previously stated, I don't regard dollars spent for research as a reliable basis for evaluating the relative research effort between companies or industries, let me give you a few figures of the magnitude of the research effort in this country today in support of this statement. Each of you can then relate for yourself, in whatever manner you see fit, the research effort of your company.

1. The nation's expenditures for research, including governmental expenditures, have tripled in the past decade and today are running at an annual rate of $9 to $10 billion dollars. This is almost the same annual rate as total expenditures for advertising and almost the same annual rate as total sales of the paper and allied products industry.

2. Expenditures for research have been increasing at a 10% annual rate whereas the over-all economy has grown at about a 3% rate. (Source—*Stanford Research Institute Journal* 2, No. 2: 38).

I would like to now mention a few of the needs or fields for research in our industry as I see them.

1. Above all, there is the continuing need for research to enable us to supply the ever-changing needs of our customers.

2. We must exert constant ingenuity to enable paper to compete with other materials.

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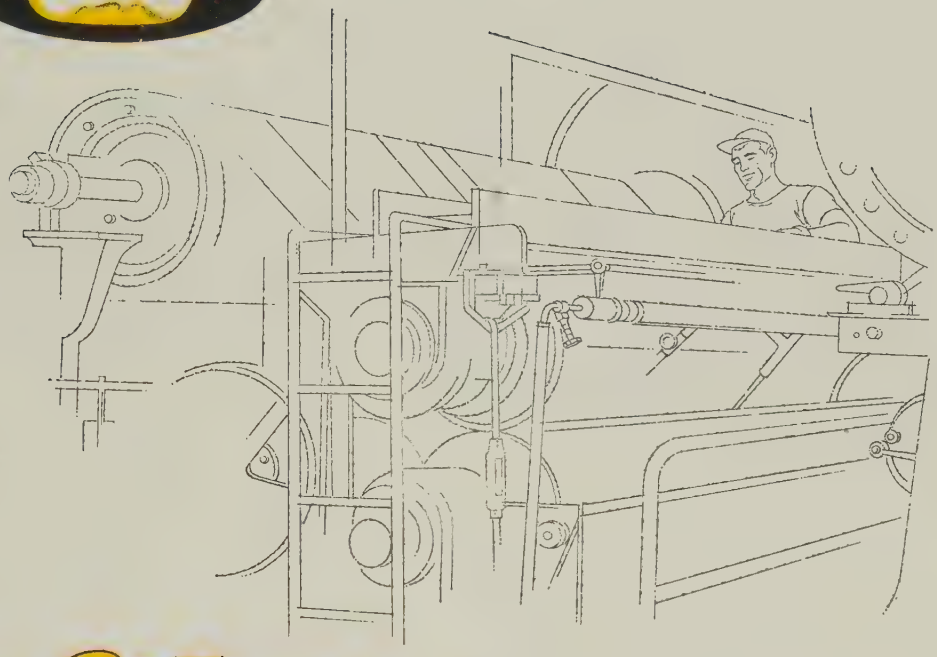

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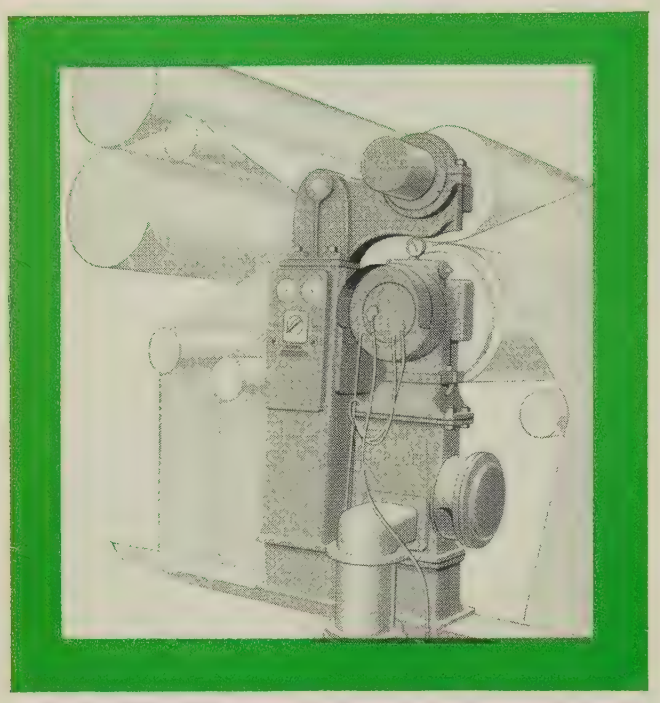

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3. We must learn how to use paper in combination with chemical additives and other new materials such as metal foils and plastics as they are developed in order to develop new uses for paper.

4. If our industry is to continue its growth, we must develop new paper qualities and new and improved converted products made from paper.

5. With increasing capital costs, the cost-price squeeze, and the keen competition that exists, we must exert every research means to improve our chemical and physical processes, increase our efficiencies and innovate new concepts if we are to remain competitive and continue to grow.

6. We haven't scratched the surface of the research potential that exists in forest genetics and the growth and utilization of wood in all of its ramifications.

7. There is an enormous research potential in the utilization of all the other raw materia's we use, including substitutes.

8. With the continuing increase in distribution and material-handling costs, we must develop new, more efficient and less costly methods to move the thousands of tons of material we mass produce or use in producing and distributing our end products.

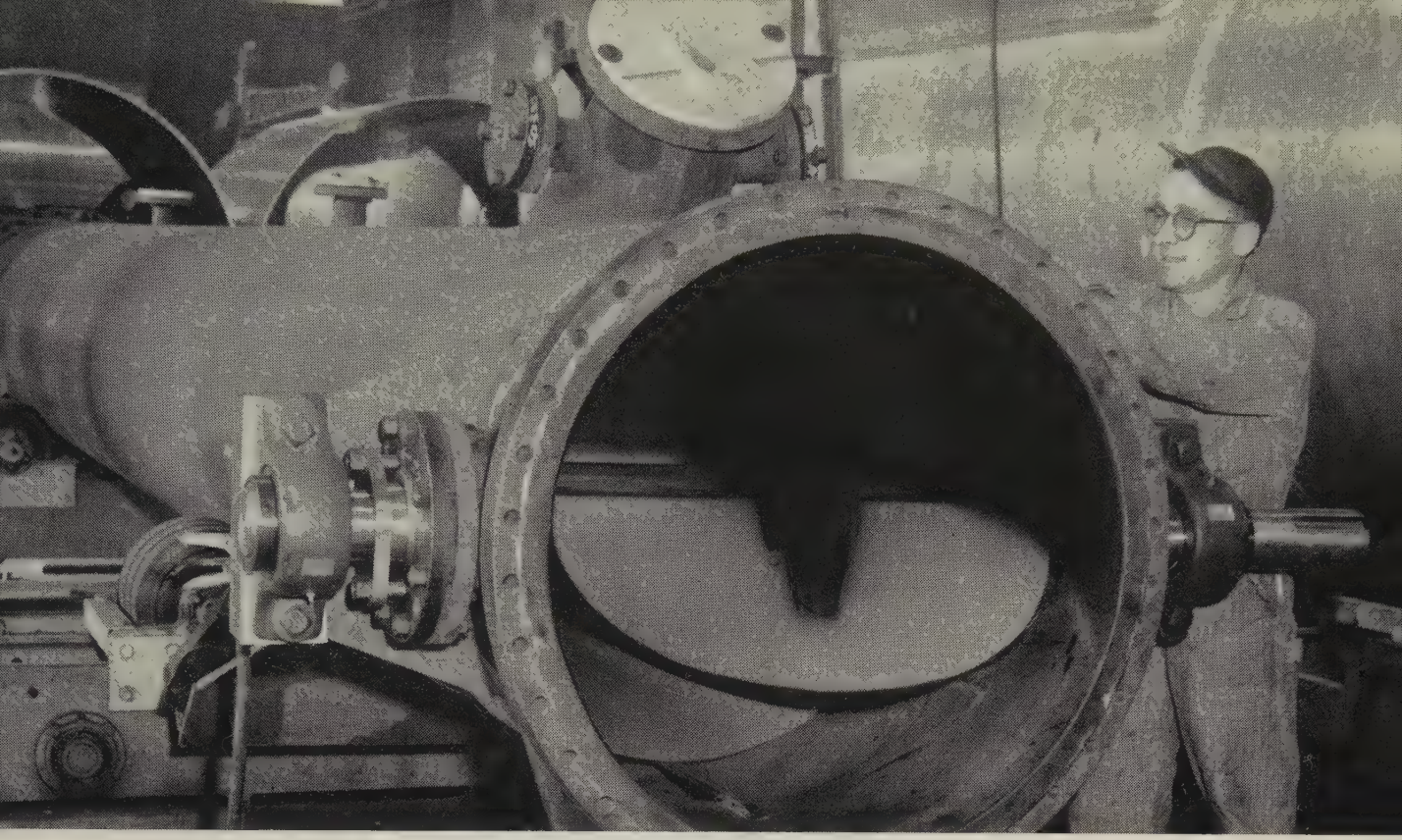
9. We must do more fundamental research or support such effort by outside agencies to better understand the molecular structure of wood, the chemistry of our pulping processes and the physical processes of papermaking.

10. We should learn how to utilize in our industry the products of research from other industries, including such things as atomic energy, electronics, plastics, and metallurgy.

11. Finally, there is the tremendous research potential of learning how to use and market the other 50% of the tree that we presently burn as fuel or discharge to the atmosphere or sewers with attendant stream and air pollution problems and expense. I am thinking of the chemical by-product potential of the resins, lignins, wood sugars, and other organic compounds that are in every stick of wood we process into chemical pulp but which we do not now economically utilize. Look what research has done for coal tar, petroleum and the oat hull. We have the same research potential and the opportunity to create a complete new industry and additional source of profits within our affairs without using one more pound of wood than we now bring into our mills for the manufacture of pulp.

In conclusion, in the technological and fast moving age in which we are living, it is my opinion that any management that neglects research will not continue to be management for very long—in fact, there might not be any company for them to manage 10 years from now. Management, therefore, looks to the members of its research staff to see to it that the function of research is understood and not neglected, to guide it in what directions research effort is needed, and to give the resulting program proper supervision in order that the research department becomes another link in the chain of facilities, forest, and people which are geared to the purpose of keeping a corporation progressive, healthy, competitive, and young.

Presented at the APPA-TAPPI Research Forum held in New York, N. Y., Feb. 26, 1959.



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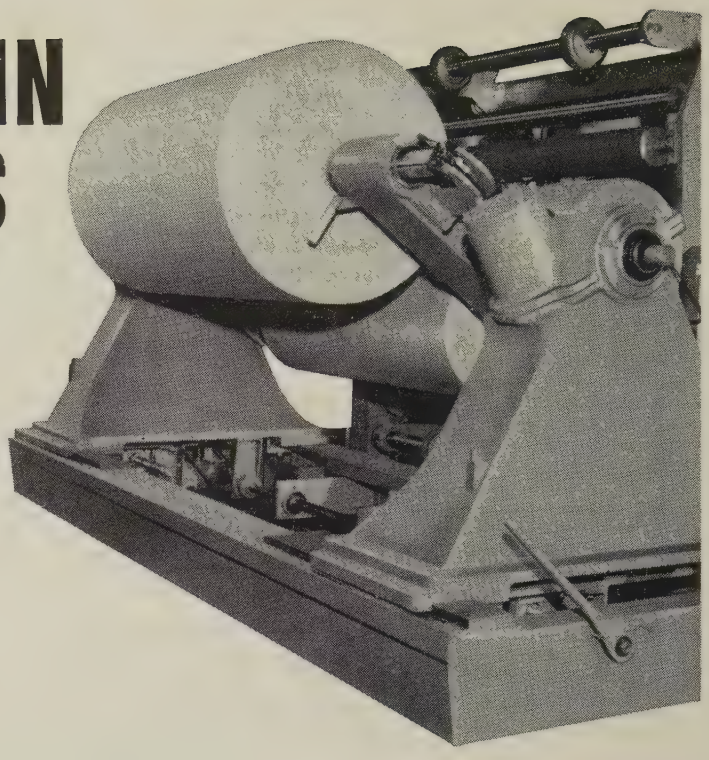

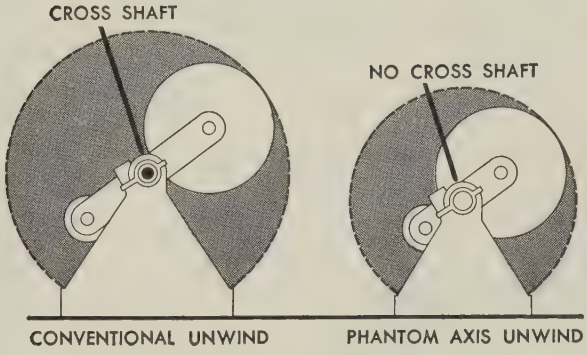

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Write, or phone Randolph 2-0200, for illustrated technical data giving complete information on the new Phantom Axis Turret Unwind Series, and its companion unit, The Egan Phantom Axis Turret Winder.

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SOMERVILLE, NEW JERSEY

CABLE ADDRESS: EGANCO—SOMERVILLE (NJER)

MANUFACTURERS OF PAPER CONVERTING MACHINERY: COATERS, LAMINATORS, TREATERS, GUMMERS, SATURATORS, EMBOSSERS, UNWINDS, WINDERS, DRYING SYSTEMS, AND OTHER COMPONENTS.

REPRESENTATIVES: MEXICO, D.F.–M.H. GOTTFRIED, AVENIDA 16 DE SEPTIEMBRE; JAPAN–CHUGAI BOYEKI CO., TOKYO. **LICENSEES:** GREAT BRITAIN–BONE BROS. LTD., WEMBLEY, MIDDLESEX; FRANCE–ACHARD-PICARD, REMY & CIE, 36 RUE D'ENGHIEN X, PARIS; ITALY–EMANUEL & ING. LEO CAMPAGNANO, VIA BORROMEI 1 B/7, MILANO; GERMANY–ER-WE-PA, ERKRATH, BEI DUSSELDORF.

Slashes Wax Bill 40% with Cities Service Pacemaker Wax

Wabash gets best quality ever!

Wabash Fibre Box Company is not the kind of firm that will sacrifice quality for the sake of price. Quality and rapid delivery are the cornerstones upon which it has built a huge and thriving business.

So when Wabash finds a way to cut its wax bill 40% without sacrificing quality, that's news!

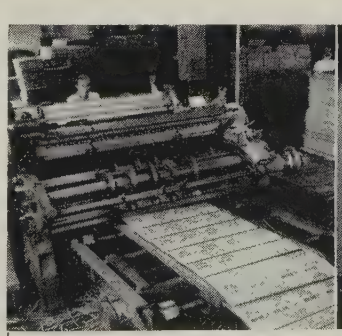
The secret is this: Using Cities Service Pacemaker 53, Wabash has been able to achieve a smooth glossy coating on its corrugated boxes *without deep penetration.* The quality of the wax is such that you simply don't need to use as much, and there's never a problem of flaking or chipping.

Another point that Wabash praises is service. Because it is locally warehoused, Cities Service Pacemaker Wax can be delivered in the shortest possible time, thus enabling Wabash to uphold its own delivery schedule, which includes overnight service within a radius of 200 miles.

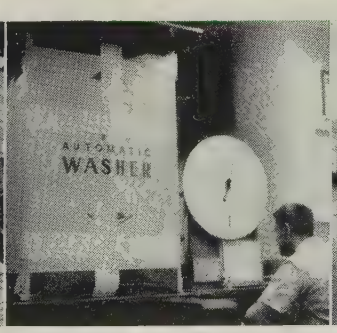
If you're looking for hard-gloss, non-flaking wax that can reduce consumption and eliminate the difficulties that often characterize waxing operations, investigate Cities Service Pacemaker Waxes. Call in a Cities Service Representative from the nearest office. Or write: Cities Service Oil Company, Sixty Wall Tower, New York 5, N. Y.

CITIES SERVICE

QUALITY PETROLEUM PRODUCTS



From Bananas to Baseball Bats! Last year, Wabash produced over 600-million feet of corrugated box for virtually every type of packaged product.



Rigid Laboratory Testing controls all Wabash boxes. Same testing led to selection of Cities Service Pacemaker Wax and 40% cut in wax consumption.

Fast Service has made Wabash famous. An order received today can be delivered tomorrow, anywhere within 200 miles if printing dies are on hand.

SCREW PRESS WASHER

by **VALLEY**

Ever think of adding a Screw Press to your present washing system?

It will take the *last* remaining liquor out!

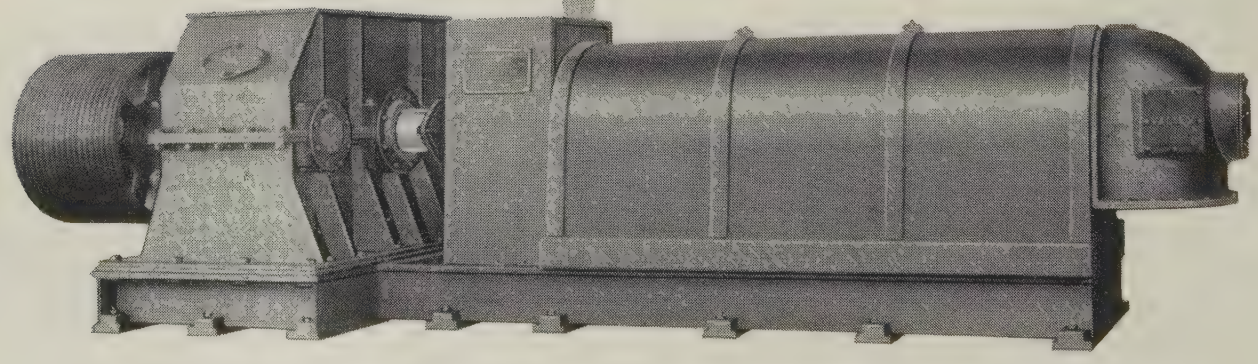
And *save* you water!

And *save* you steam!

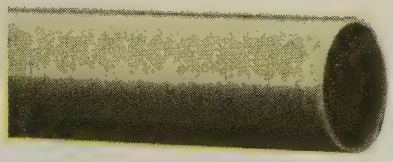
Why not investigate?

Direct your inquiry to—

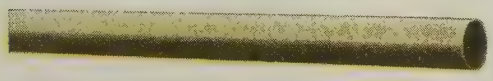
VALLEY IRON WORKS COMPANY
Appleton, Wisconsin



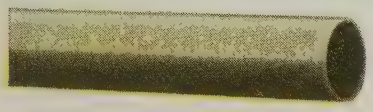
VALLEY SCREW PRESS WASHING SYSTEM



STRONG as steel pipe



. . . at one-eighth the weight!



Circumferential Tensile Strength . . . 80,000 psi

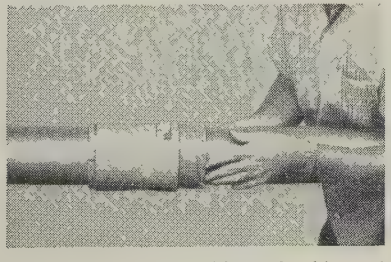
BONDSTRAND®

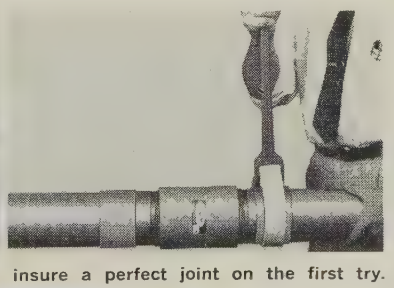
the revolutionary fiber glass reinforced epoxy pipe for corrosive service

114

Here's a pipe that holds up indefinitely under the corrosive action of many salt, acid and alkaline solutions . . . that can't contaminate or flavor the piped material . . . that is rigid enough to resist sag, cold flow or deformation – flexible enough to follow normal ditch contours . . . that remains smooth and unclogged throughout its entire service life . . . that won't leak, even near its burst pressure.

Easy to install, with choice of locking wedge or threaded fittings.





Simple instructions with each shipment insure a perfect joint on the first try.

IN THE PAPER INDUSTRY...

The resistance of BONDSTRAND pipe to chemical solutions and wet environments make it well suited to pulp and paper operations, including the transportation of pulp, stock, water, wastes and dyes. Tests are recommended for liquor applications.

Amercoat® CORPORATION

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921 Pitner Avenue, Evanston, Illinois
360 Carnegie Avenue, Kenilworth, New Jersey
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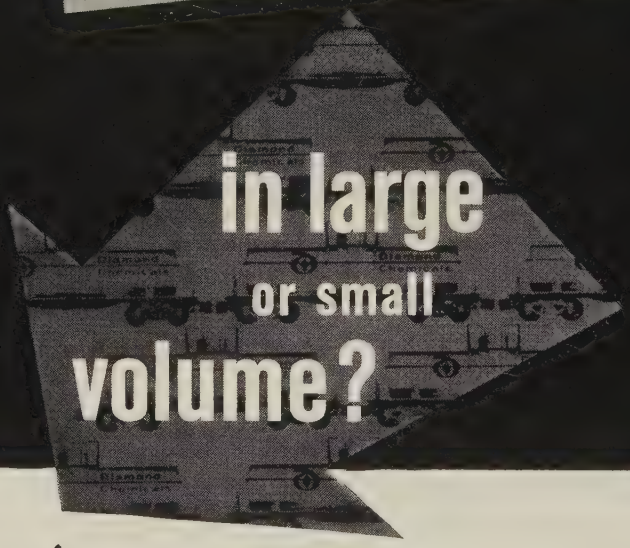
6530 Supply Row, Houston, Texas

A Subsidiary of American Pipe & Construction Company

CHLORINE?

FAST?

in large or small volume?



call Diamond

for fast, efficient, dependable service. Get immediate shipment of the chlorine you need in any quantity from one of our four strategically located Diamond plants. You can depend on Diamond to meet your caustic soda requirements, too. DIAMOND ALKALI COMPANY, 300 Union Commerce Building, Cleveland 14, O.

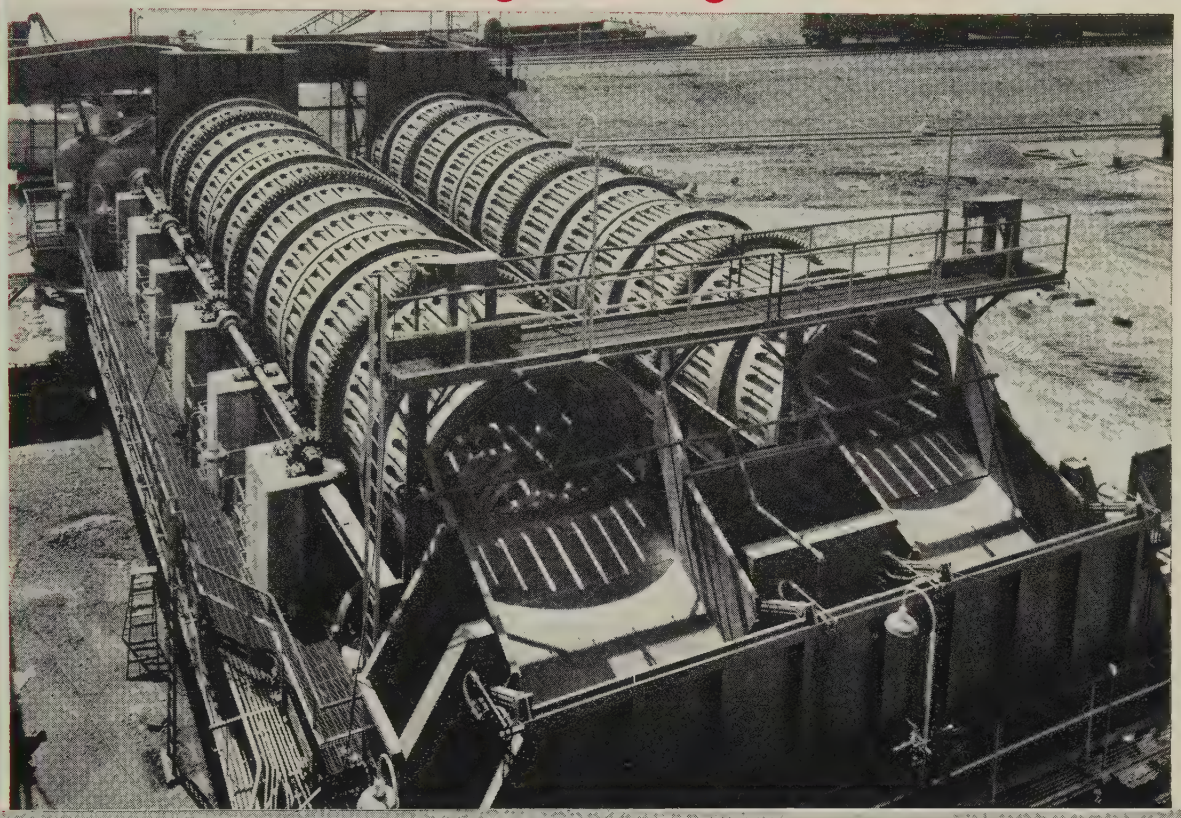
Chlorine Plants: Edgewood, Md. • Deer Park, Texas • Muscle Shoals, Ala. • Painesville, Ohio.

Sales Offices: Chicago, Cincinnati, Cleveland, Houston, Memphis, New York, Philadelphia, Pittsburgh, St. Louis.

Diamond Chemicals

The "Weldrum" Barker...

Progressive Engineering in action



These 67½ feet three-section "Weldrum" Barkers are installed at Bowaters Southern Paper Corporation, Calhoun, Tennessee.

Reducing the customer's cost of drum barking wood . . .

. . . is the primary purpose behind the design of every "Weldrum" Barker.

This continuing research may be called progressive engineering and it is done in full co-operation with the engineering staffs of our major pulp and paper producers.

Actually, our program of modifying and improving the "Weldrum" Barker has produced unparalleled savings in drum barking costs.

Four basic models cover practically all drum barking operations:

- *12′ by 45′ two-section drum for most soft woods*
- *12′ by 45′ two-section drum with solid plate inlet section for extra washing or frozen wood*
- *12′ by 67½′ three-section drum for highly resinous wood*
- *12′ by 67½′ three-section drum for hard woods*

For specific information and detailed estimates, contact your nearest Ingersoll-Rand office or write direct to Canadian Ingersoll-Rand Co. Limited, 620 Cathcart Street, Montreal, Canada.

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Canadian **Ingersoll-Rand** Co. Limited

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CALGARY
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CLINTON can do it with Corn

simple? no!

as complex as life itself

At Clinton we learn new things about corn almost every day.

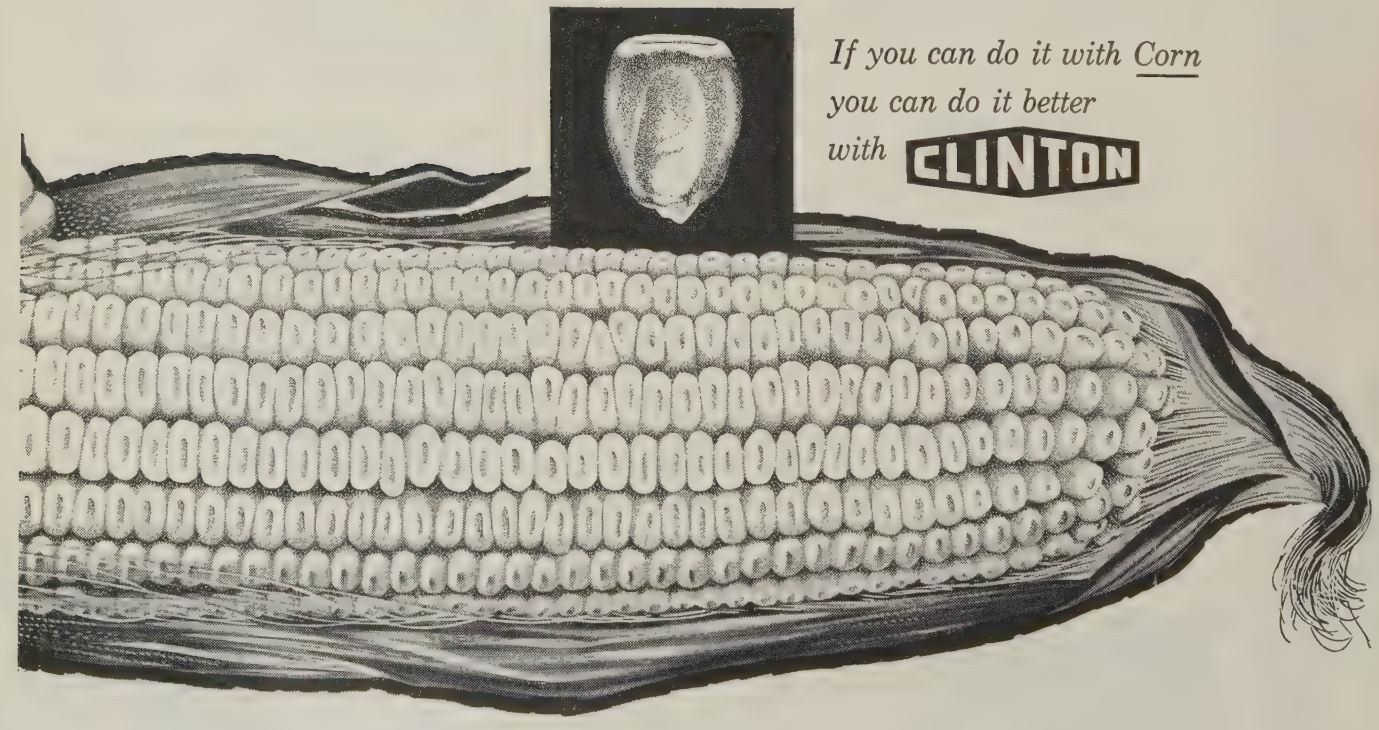
Corn is sustenance and shelter. It is clothing and confections—bread and beer. Corn is life—but only with the help of man. Its seed left in the field will wither and rot—but planted and cultivated by man it will drive roots three feet into the ground and stalks as high as fifteen feet into the air. It will thrive and create the raw materials for the well-being of man.

Clinton serves the PAPER industry

Clinton starches and dextrins will always meet your most exacting specifications. Consult your Clinton salesman. He will provide product information, arrange for prompt technical service, or assist you in any way possible.

CLINTON CORN PROCESSING COMPANY
CLINTON, IOWA

CORN SYRUPS • DEXTROSE • STARCHES • DEXTRINS
SUGARS • OILS • LACTIC ACID
AND OTHER PRODUCTS FROM CORN



If you can do it with Corn
you can do it better
with CLINTON

we're close to the paper industry in more ways than one!

The map tells you at a glance how well we're situated to give you *fast service* from nearby laboratories and warehouses when you want help in matching shades or same-day shipment of a needed dye.

But it doesn't show how close to your day-to-day operating problems we really are!

Regular customers may have noted, for instance, that the formulations we suggest are more than good, economical working formulas. *Wherever possible they're based on dyes we know you have on hand!* Many mills tell us this regularly saves them dollars in inventory.

This important service extra is indicative of the friendly, helpful relationship we maintain with all of our customers. It's one more reason why National Paper Dye service . . . developed by long experience . . . can't be beat. One more reason why it always pays to call National Aniline.

NATIONAL ANILINE DIVISION

40 RECTOR STREET, NEW YORK 6, N. Y.

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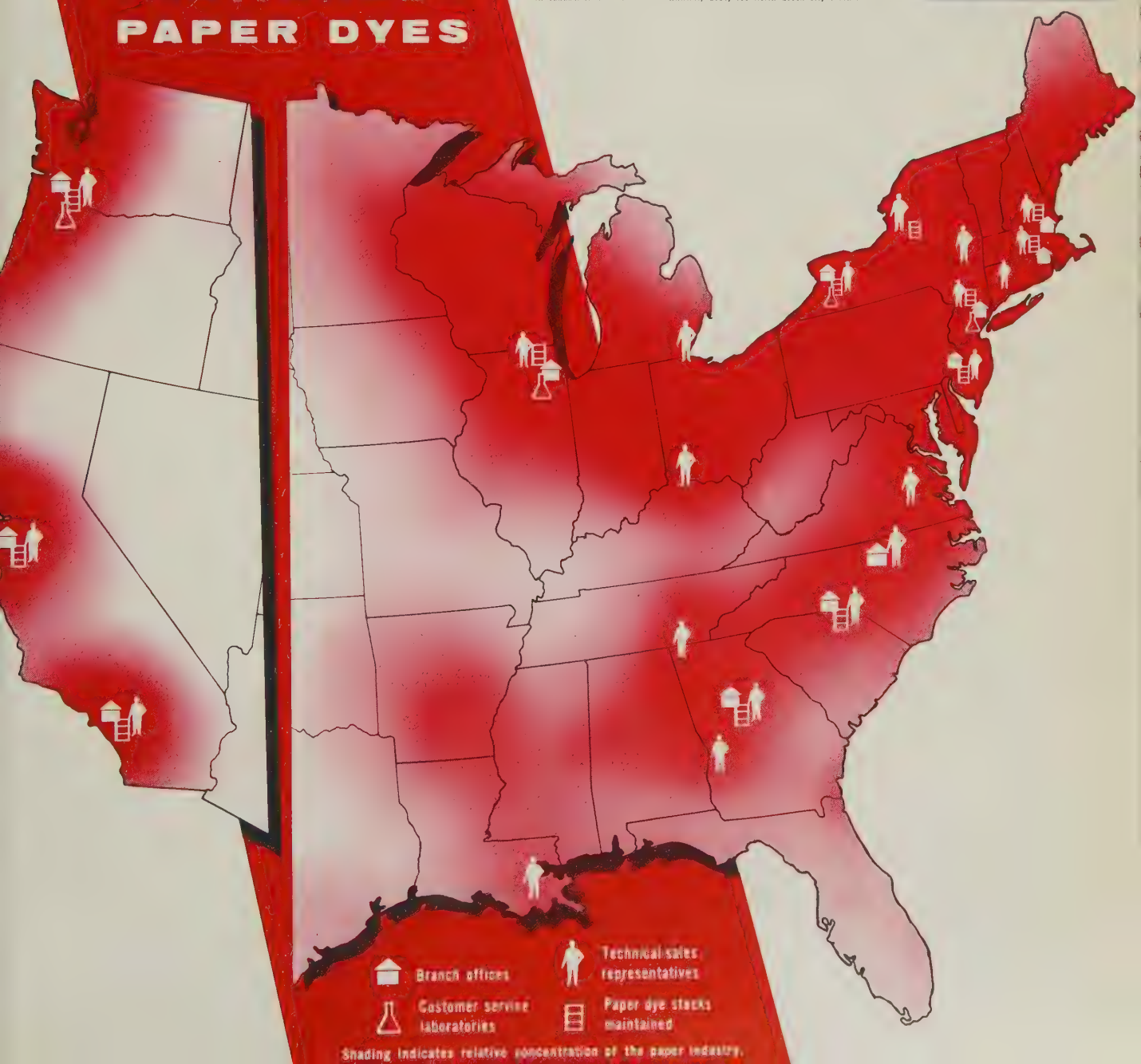
Allied Chemical

NATIONAL PAPER DYES


Branch offices
Technical sales representatives
Customer service laboratories
Paper dye stocks maintained
Shading indicates relative concentration of the paper industry.

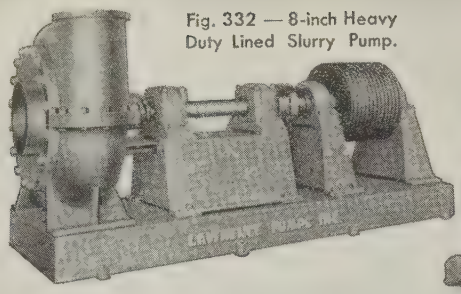


Fig. 332 — 8-inch Heavy Duty Lined Slurry Pump.

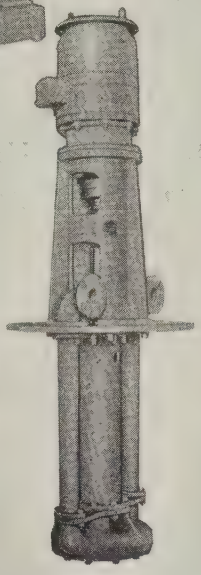
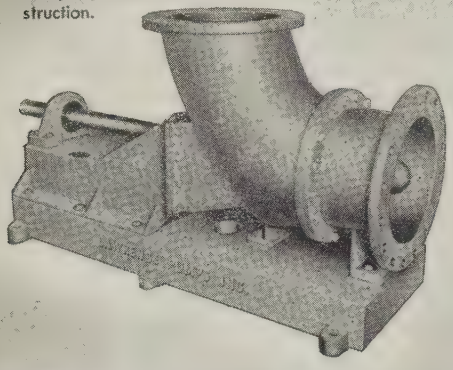


Fig. 244 — 4-inch Vertical Submerged Pump With No Bearings Below the Cover Plate.

Fig. 285 — 5-inch Vertical Top Suction Stock Pump.

Fig. 333 — 24-inch Horizontal Circulating Propeller Pump of Nickel Alloy Construction.



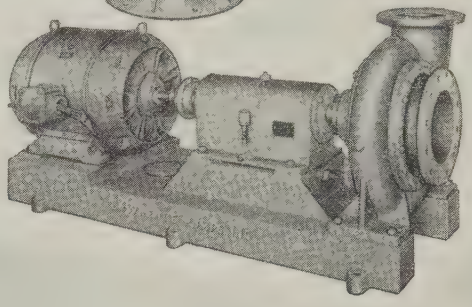


Fig. 337 — Lawrence 10-inch Heavy Duty Stainless Steel Chemical Pump.

SPECIAL HANDLING
for the pulp and paper industries

LAWRENCE PUMPS *handle every liquid and fluid material used in pulp and paper mills*

To pump acids, caustics, stocks, resins, sulphurs, slurries — hot (1500°F), cold (—347°F), or extremely viscous — requires engineering skill normally not available from a pump manufacturer. Lawrence engineers have specialized in this difficult field for more than 90 years. It may almost be said — there is no "pumpable" fluid with which Lawrence engineers have not had repeated and successful experience.

Lawrence Pumps are designed for either horizontal or vertical operation. Every pump is custom built from the corrosion- and abrasion-resistant metals best-suited to the fluid to be pumped.

If you have a particularly difficult pumping problem, we can save you both time and money. Write us the pertinent details. No obligation.

Send for Bulletins 203-6 and 205-3 for a complete summary of acid and chemical pump data.

LAWRENCE PUMPS INC.

357 Market Street, Lawrence, Massachusetts

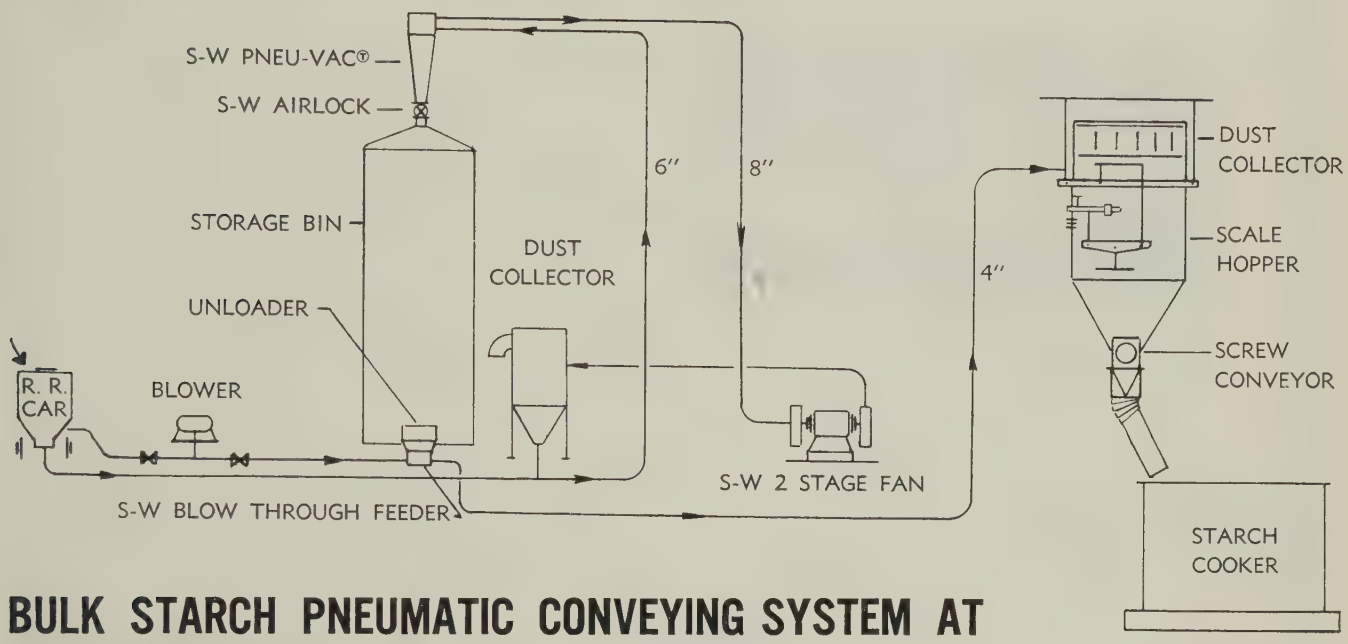
SPROUT-WALDRON

BETTER FIBERS

SINCE 1866

REFINERS • DIGESTERS • CONVEYORS • FEEDERS • SCREENS • MIXERS • DRAINERS • FIBER PRESSES • STOCK PROPORTIONERS

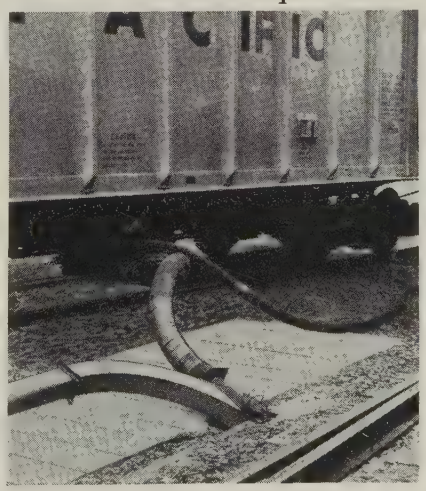
Published in the interest of better pulp and paper processing by Sprout, Waldron & Co., Inc., Muncy, Pennsylvania



BULK STARCH PNEUMATIC CONVEYING SYSTEM AT WEYERHAEUSER TIMBER COMPANY

Lower cost, less contamination, cleaner and safer working conditions . . . are among the advantages cited by the Pulp Division, Weyerhaeuser Timber Company, Springfield, Oregon, in describing its new bulk starch conveying and storage system, designed and engineered by Sprout-Waldron. The system is used for unloading bulk starch from hopper bottom cars as well as for taking the starch to bulk storage and from there to cooking vats in weighed quantities. According to the engineers at Weyerhaeuser, the new method uses pushbuttons and automatic controls to take the place of the back-breaking toil and guesswork.

Weyerhaeuser unloads an average of one 50 ton Airslide car per week. Unloading time, including hookup, changing hoppers, etc. is between seven and eight hours with the actual unloading rate set at 10 tons per hour. Prior to using Airslide cars, ordinary hopper cars were used. These required con-



tinuous rodding to get the starch to unload and resulted in unloading times of nearly double that which is now secured through the use of Airslide cars.

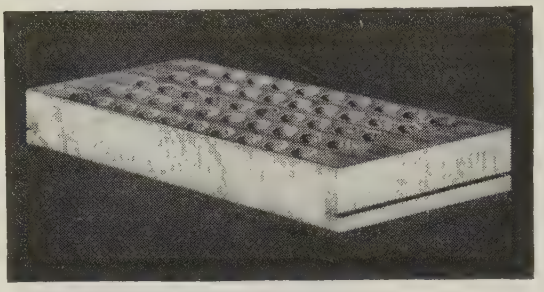
Key equipment in the bulk unloading method are the Sprout-Waldron Pneu-Vac® negative pressure system which unloads the Airslide cars and delivers the starch into the glass-lined storage bins; and the Sprout-Waldron Pneu-Flo® positive pressure system which actuates the car and conveys the starch from the bin unloader to the scale hopper.

For details on how Sprout-Waldron pneumatic handling systems can cut your conveying and storage costs, contact your Sprout-Waldron representative.

The following specific bulletins may be of interest. F-19 Handling Starch at Morningstar-Paisley. I-28 Practical Pneumatic Conveyor Design. 18-E Pneu-Vac Negative Pressure Pneumatic Systems.

BF/201

Greater Savings with
W-OK SUCTION BOX COVERS



Send detailed blueprints if possible when requesting quotations.

LONGER WIRE LIFE due to low friction surface

LONGER COVER LIFE average period between re-surfacings 10-12 months

SMOOTHER SURFACE results in power saving

SUCTION SURFACE can be increased substantially

DOES NOT CRACK when drying

THE FEDERAL MACHINERY & MANUFACTURING COMPANY LTD.

72 QUEEN ST., LENNOXVILLE, P. Q.

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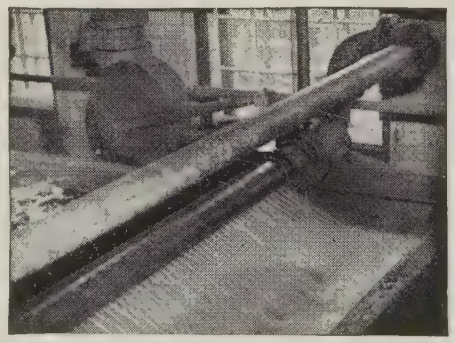
LENNOXVILLE, P.Q. & P.O. Box 635 NEWPORT, VERMONT

TESTED and PROVEN!...

IN CANADIAN AND UNITED STATES MILLS



A perforated pipe extending the whole length of screens, oscillates at slow speed, at very low water pressure distributing water over entire surface of screens, breaking up fibre bundles and separating them out for more complete screening.

FEDRALCO

KARLSTROM PERSSON WATER DISTRIBUTION SYSTEM FOR FLAT SCREENS

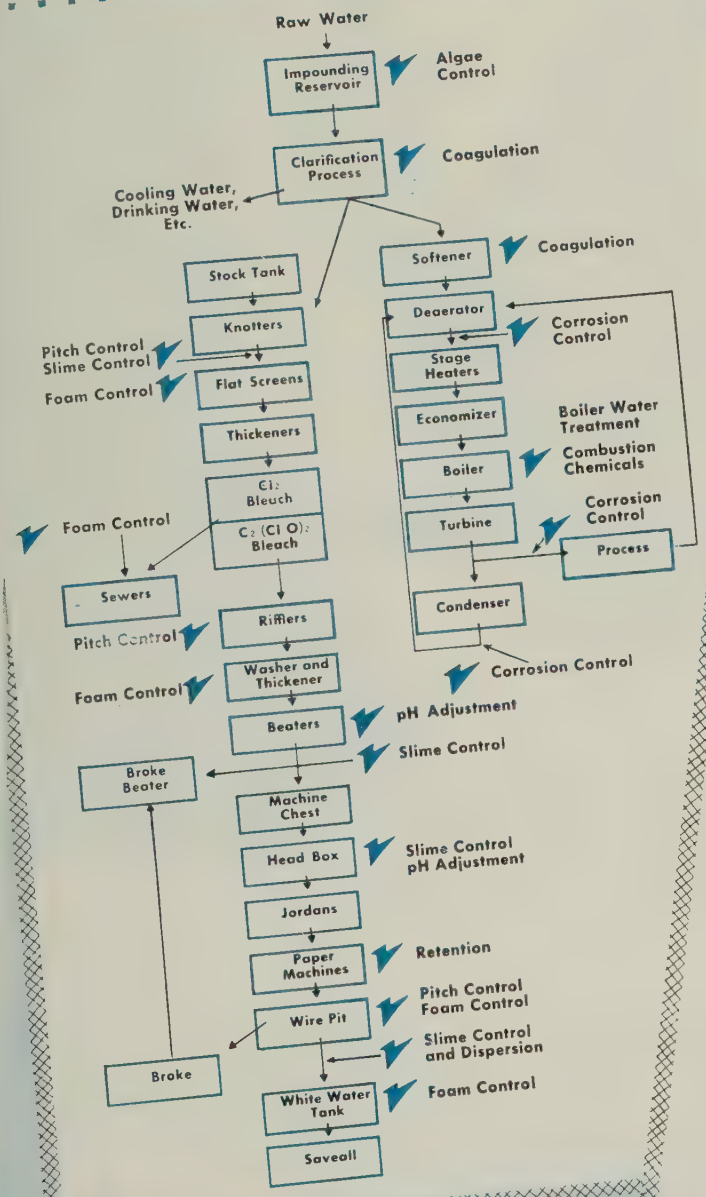
- ✓ No Clogged Plates
- ✓ Cleaner Screening
- ✓ Lower Costs
- ✓ Higher Production

HERE IS THE

COMPLETE *Nalco* PROGRAM

for Better Products at Lower Cost

. . . IN A TYPICAL MILL



NALCO has the *widest variety* of formulas to assure results in your mill, too. Here are some examples . . . representative Nalco products listed under headings which indicate the job they do. And the chart at left tells you where they are used. Your Nalco Representative will tell you more about them — or write direct to Nalco.

ALGAE CONTROL
Nalco Cuprose · Nalco 21-S · Nalco 201 · Nalco 234 · Nalco 236 · Nalco 237

COAGULATION
Nalco 600 · Nalco 650 · Nalco 680

COMBUSTION CHEMICALS
Nalco 155 · Nalco 156 · Nalco 156-C

FOAM CONTROL
Nalco 71 · Nalco 71-B · Nalco 71-C · Nalco 71-D5 · Nalco 71-K · Nalco 72

CORROSION CONTROL
Nalco 19 · Nalco 35 · Nalco 353 · Nalco 918

pH ADJUSTMENT
Nalco 680

PITCH CONTROL
Nalco 818

RETENTION AND CLARIFICATION
Nalco 600 · Nalco 650 · Nalco 680

SLIME CONTROL AND DISPERSION
Nalco 21-S · Nalco 21-M · Nalco 201 · Nalco 234 · Nalco 236 · Nalco 237

BOILER WATER TREATMENT
Nalco 75 · Nalco 718 · Nalco 728 · Nalco 752

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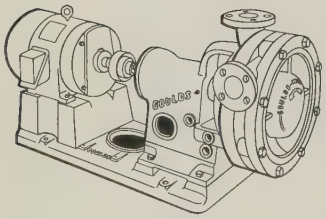
THE *Nalco*® SYSTEM . . . Serving the Paper Industry through Practical Applied Science

Nalco CHEMICALS

IS THIS HAPPENING INSIDE YOUR PUMPS?



The Goulds-Pfaudler glassed pump is available in conventional hydraulic design, simplifying installation and maintenance. Four sizes with capacities up to 700 GPM, heads up to 140 ft.

When you pump corrosives, the inside of your pump *can* look like this. Or . . .

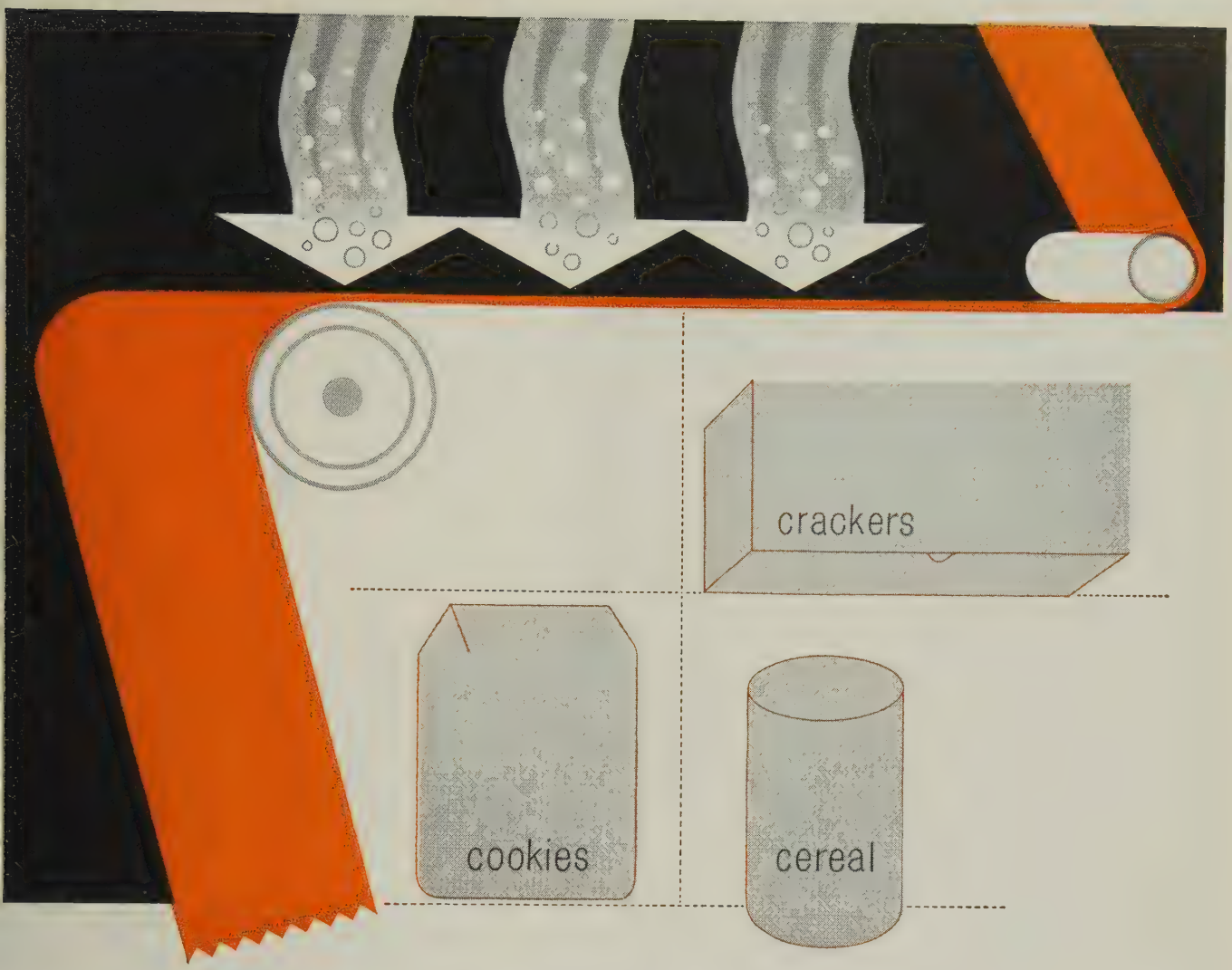
You can pump corrosives *without* corrosion with the Goulds-Pfaudler Fig. 3708 glassed pump. *Every surface that comes in contact with the pumpage* is protected by tough borosilicate glass fused permanently to the metal!

This glass-to-metal bond resists most acids at temperatures up to 350°F and alkalies at moderate temperatures.

You also prevent loss of product due to contamination, since glass is *inert*. Glass is *smooth* — discourages product adhesion and scale build-up.

For all the details, write for Bulletin 725.2 . . . plus a second booklet, "It's What's Inside That Counts," that gives you the inside story behind the new Goulds-Pfaudler glassed pump. Write Goulds Pumps Inc., Dept. TA-39, Seneca Falls, New York.

GOULDS GP PUMPS



New way to protect flavor and aroma

IONOL® CP antioxidant guards against rancidity

Now you can offer your customers in the food industry packaging materials that will increase their products' shelf life, effectively and economically. When used to impregnate food packaging materials, Ionol CP antioxidant guards against rancidity by retarding the attack of oxygen on fats at the surface of cartons and wrappers.

Ionol CP is a non-toxic, economical material which is readily applied to paper products. By test, baked goods stored at 85°F. in boxboard cartons impregnated with Ionol CP were free of rancidity at the end of 90 days. Without Ionol CP protection, packaged baked goods stored under similar conditions can rancidify within a week.

Offer your customers this effective, new packaged goods protection. Write for technical bulletins IONOL CP (SC:58-84) and IONOL CP FOR PAPER AND PAPERBOARD (SC:58-85), or contact your nearest Shell Chemical district office for additional details.

SHELL CHEMICAL CORPORATION
INDUSTRIAL CHEMICALS DIVISION

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SHELL

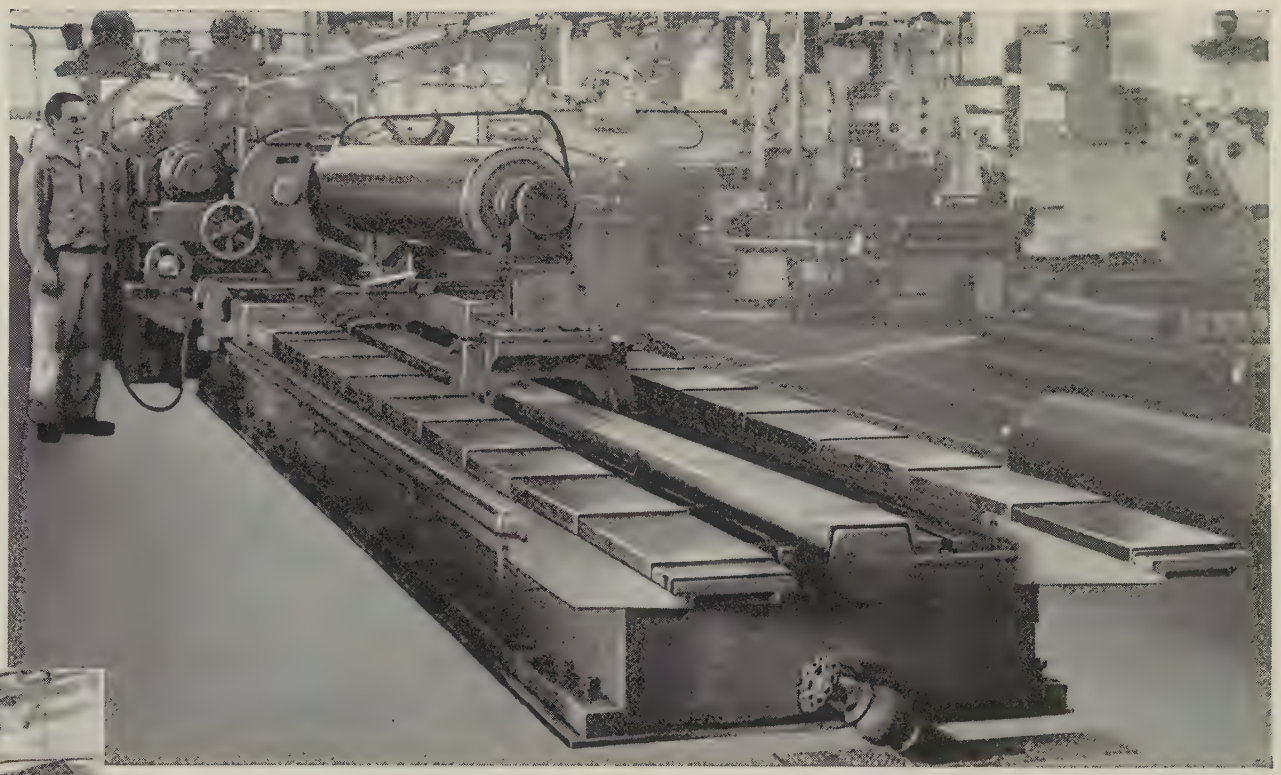
LOBDELL GRINDER

—Latest Addition to Sandy Hill's 10 Year Expansion Program

A Lobdell Roll Grinder, the most modern available, is Sandy Hill's newest acquisition in a ten year retooling program now nearing completion. It will accommodate rolls from 6 inches to 8 feet in diameter.

Sandy Hill has had long experience in studying and recommending proper crowning for rolls in each paper machine section. Now a newly designed crowning device incorporated in the new Lobdell Roll Grinder gives a full range of desirable crown curves.

An automatic wheel infeed compensates for wheel wear on chilled iron to eliminate the inaccuracies that are the most common cause of uneven caliper in the finished paper sheet.



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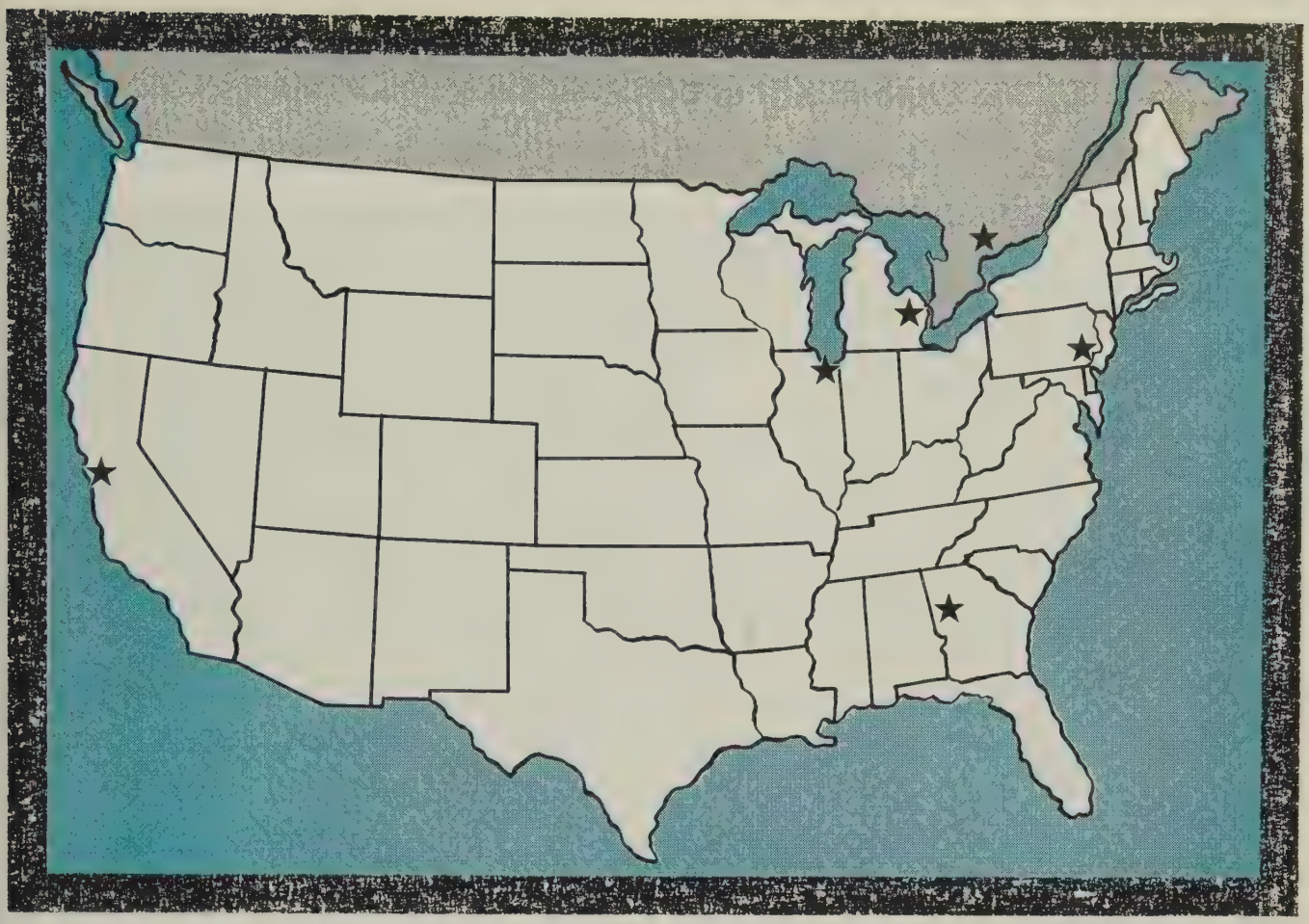

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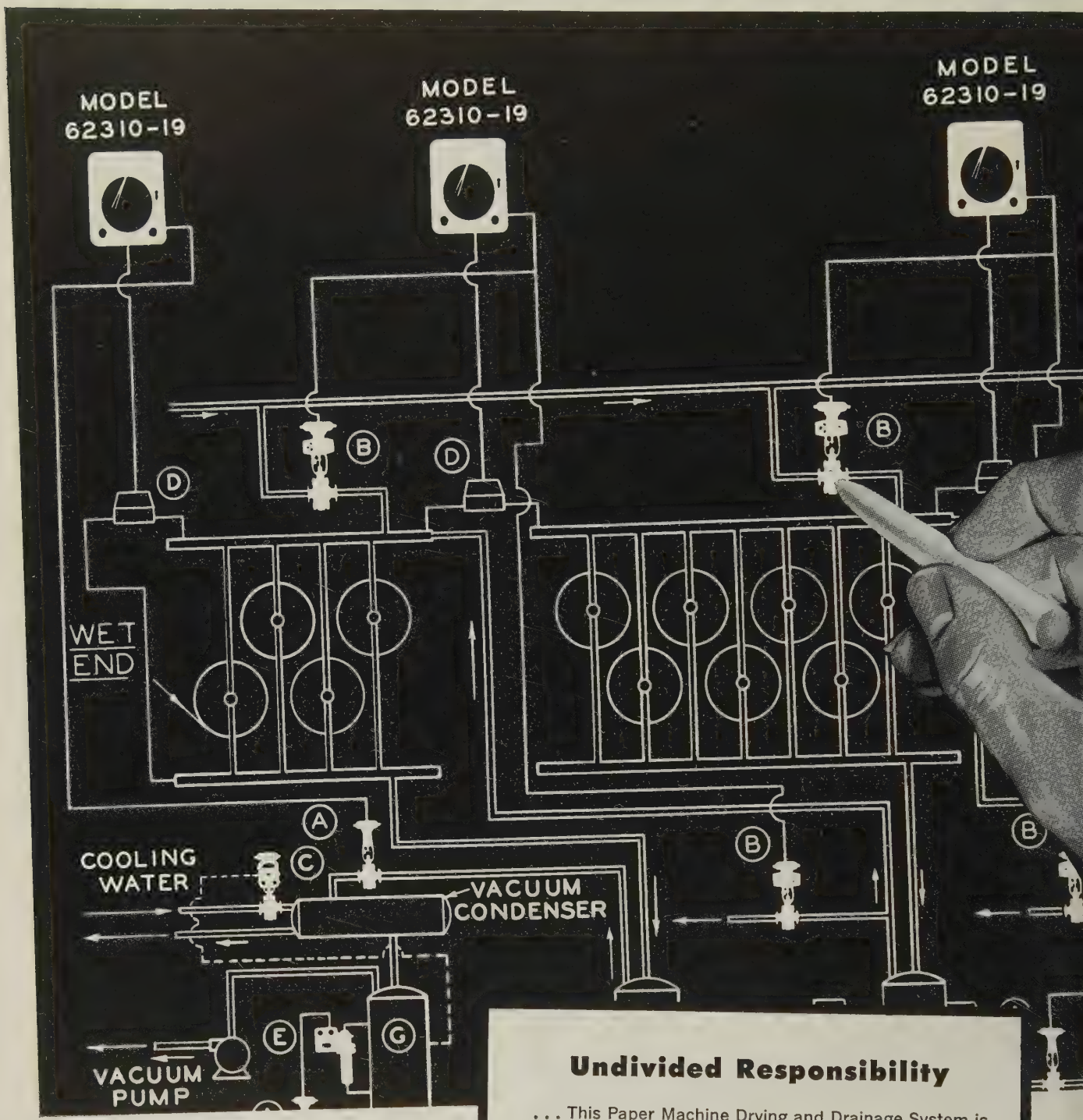

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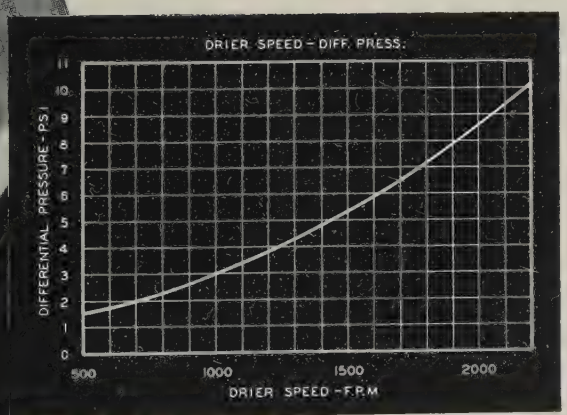


Fig. 1 indicates what minimum differential pressures are generally necessary to properly evacuate a 60" diameter drier. This is an empirical curve, but experience proves it reliable.

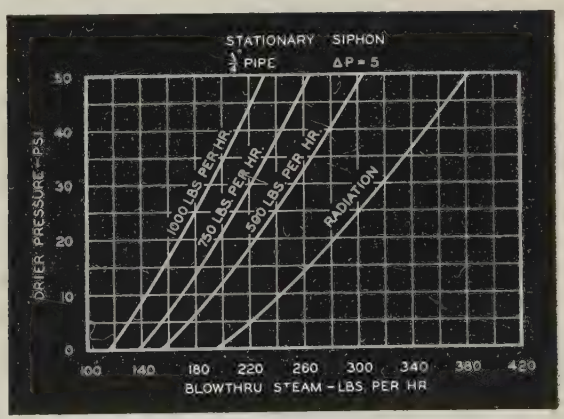
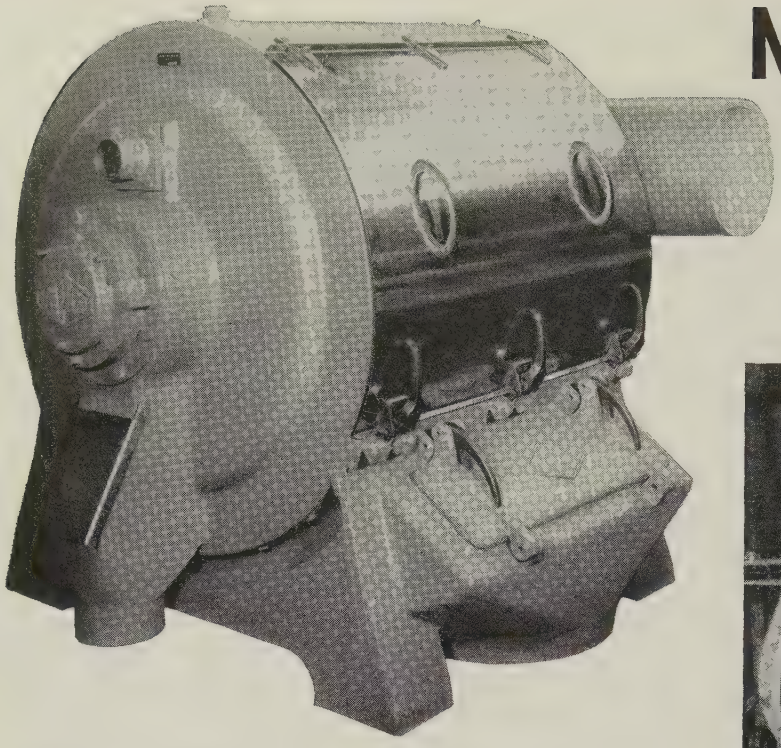


Fig. 2 shows the considerable difference in the quantity of blow-through steam when a drier is condensing and when under radiation load. These curves are also derived in an empirical manner.



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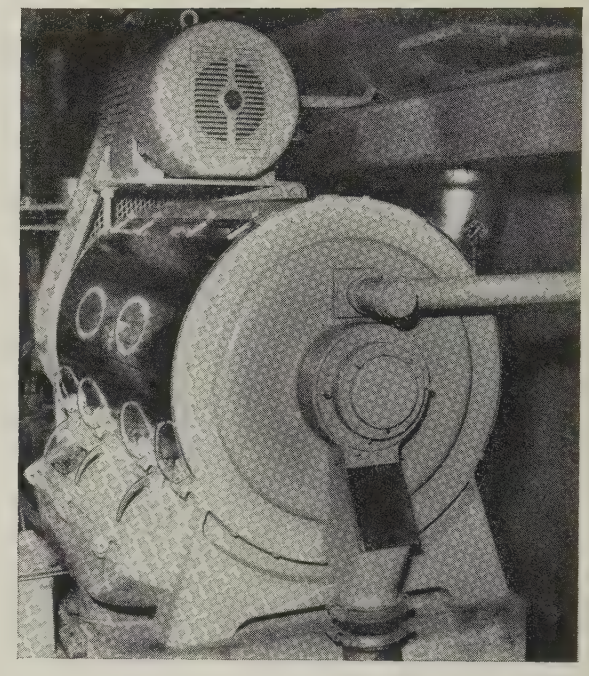

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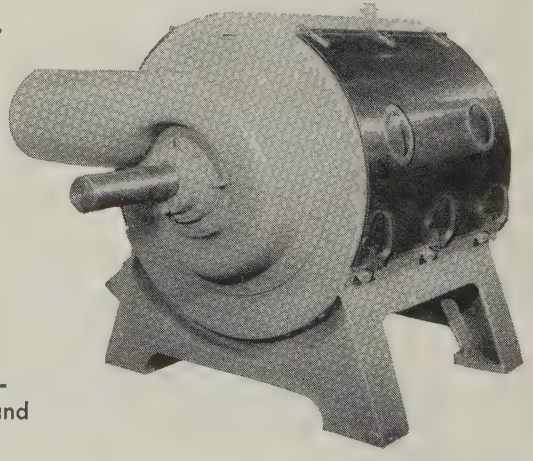
— an accessible rejects outlet for tailings inspection or sampling.



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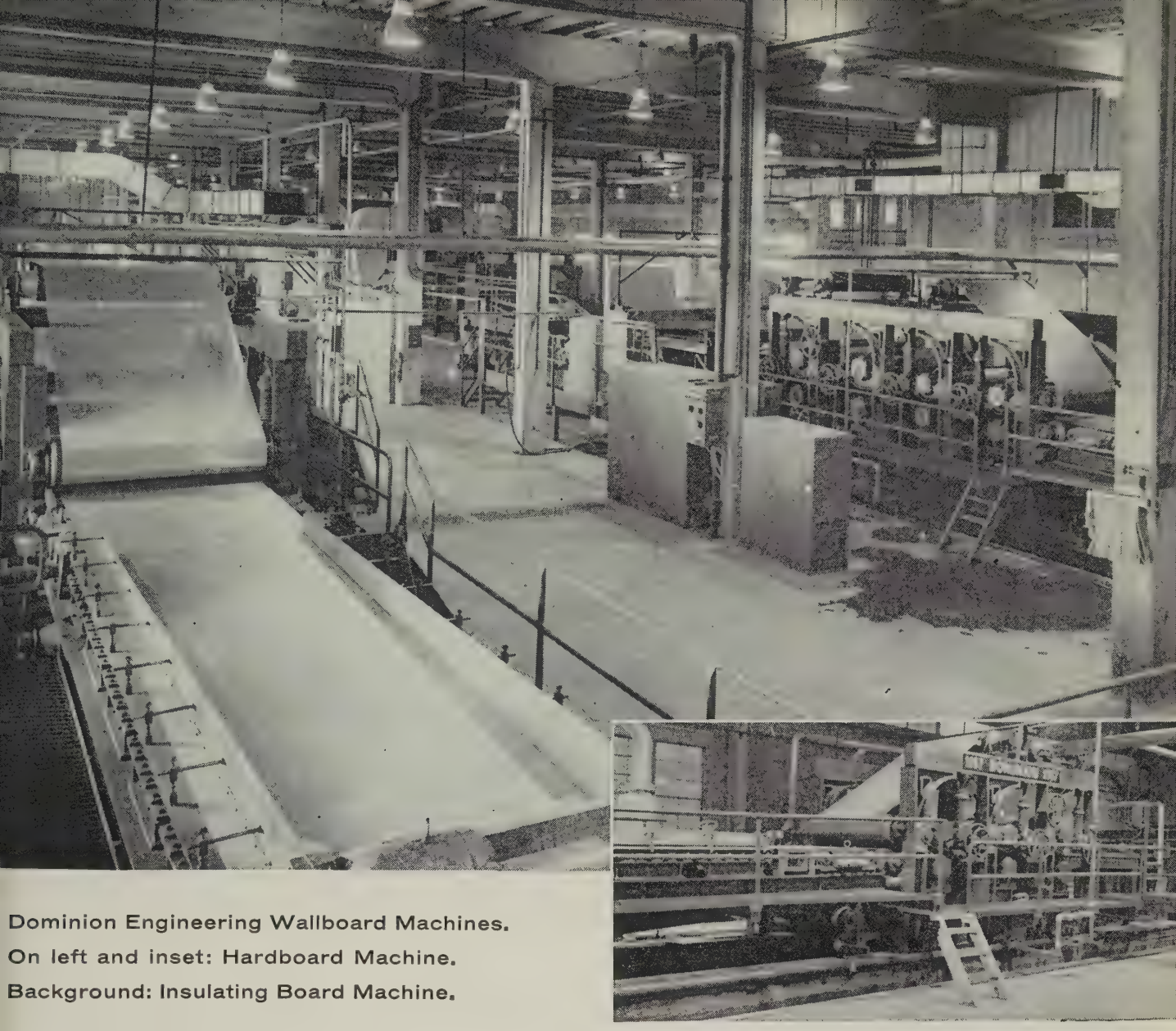

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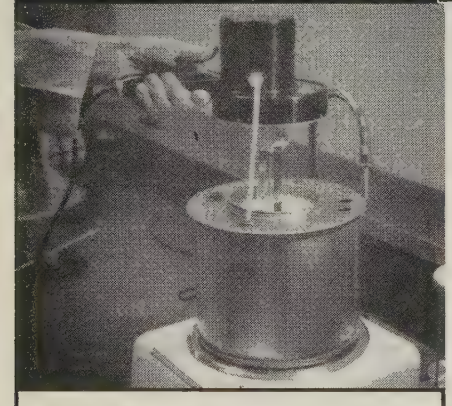

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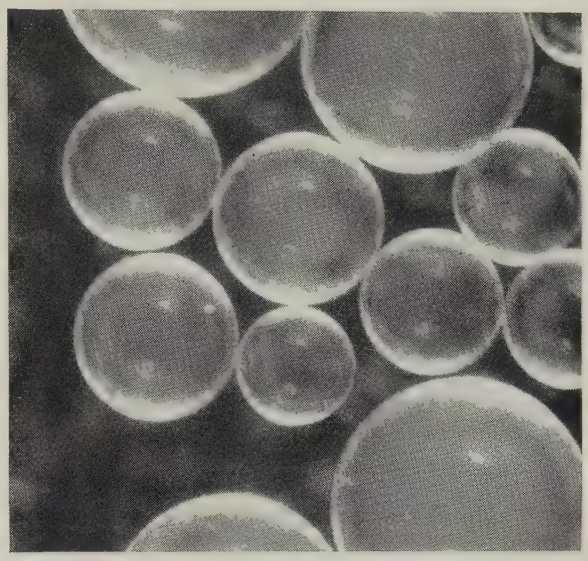

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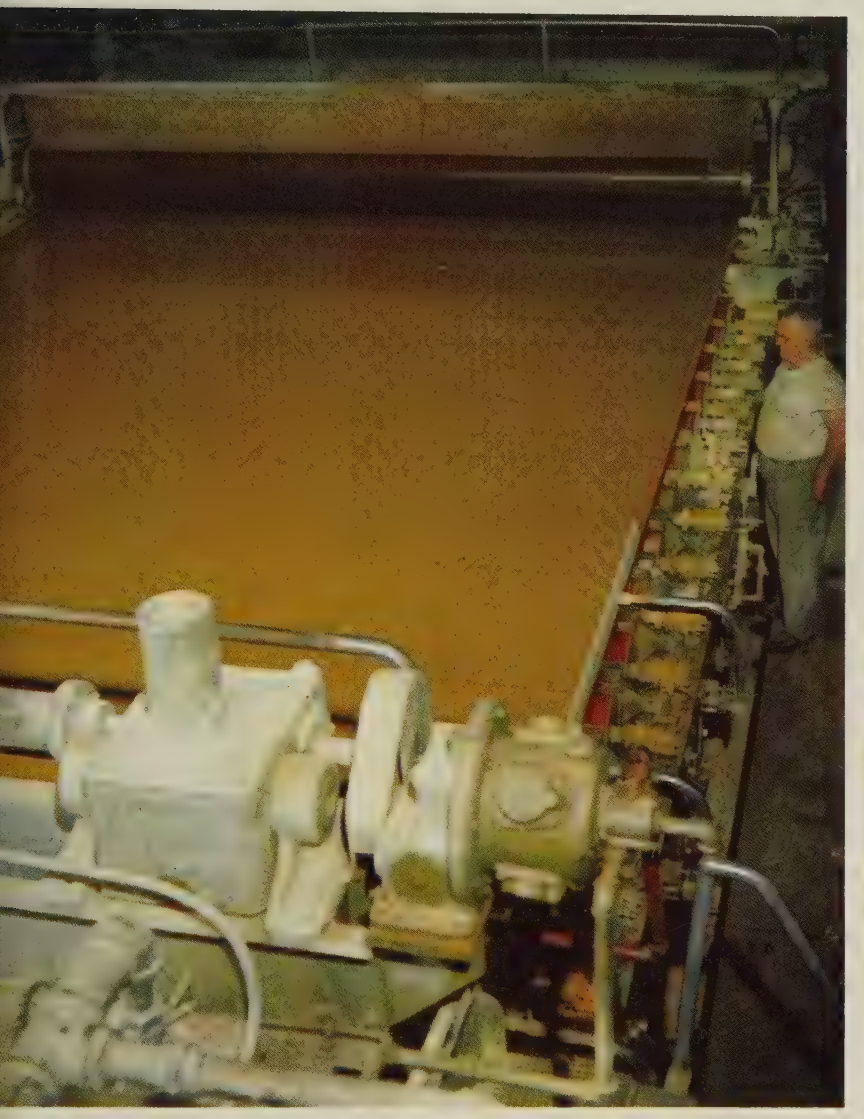

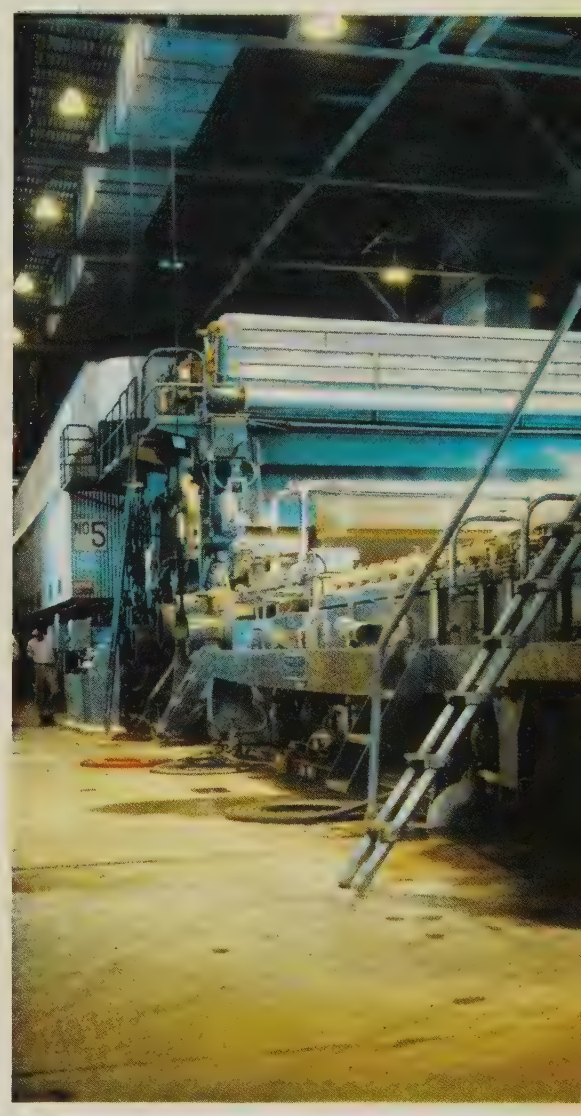

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Right, Above: *Overall view of 2000 f.p.m. machine which was completely rebuilt by Pusey and Jones for Fraser Paper, Ltd.*

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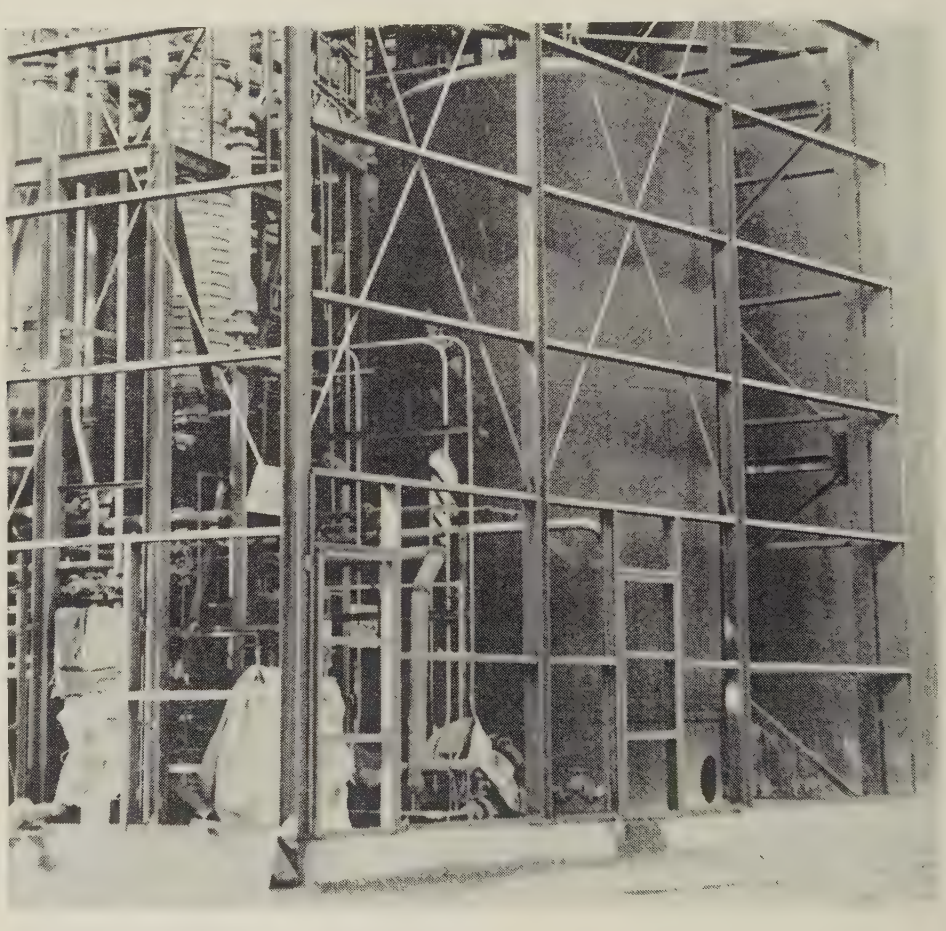

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Aldehyde, Carboxyl, Pentosan, and Degree of Polymerization Data on the ICCA "Standard" Pulps

WILLIAM L. MORROW

Aldehyde, carboxyl, pentosan, and degree of polymerization data are presented in this paper as an aid to characterizing the ICCA "standard" pulps.

THE International Committee for Cellulose Analysis (ICCA) has selected a series of "standard" pulps for use by the various committees in their work on interlaboratory evaluation of methods for characterizing cellulose. Aldehyde, carboxyl, pentosan, and degree of polymerization data are given in this paper as an aid in characterizing these pulps.

EXPERIMENTAL

Aldehyde was determined by oxidation of the pulp with a 0.01 *M* sodium chlorite solution in a sodium acetate acetic acid buffer (pH 3.52) at 40°C. (*1*, *2*).

The carboxyl content was determined by a modification of Davidson's methylene blue absorption method (*3*). A 0.1 *N* HCl solution instead of a 0.1 *N* acetic acid solution was used to minimize the adsorption of methylene blue on the glass during the photometric measurements. An automatic 1-ml. pipet, coated with a silicone fluid, was used to deliver the centrifuged methylene blue solutions to 25-ml. volumetric flasks for dilution. A Beckman Model DU quartz spectrophotometer was used for the absorbance measurements.

The pentosan content was determined by using the TAPPI distillation procedure (*4*), and determining the furfural by the orcinol method (*5*), using a calibration curve based on pure furfural.

The weight average degree of polymerization (D.P.) was calculated from cuprammonium viscosity data using the formula derived by Battista (*6–9*).

RESULTS AND DISCUSSION

Aldehyde, carboxyl, pentosans, and degree of polymerization data presented in Table I are the average of three determinations.

The high degree of polymerization of pulps 1, 2, 7, and 8 indicates that less degradation has taken place in their preparation than in the other pulps. Prehydrolysis of pulp no. 3 probably accounts for its low degree of polymerization.

The six sulphite pulps cover a wide range, indicating that mill operating conditions may be varied to give almost any desired product. The high carboxyl and high aldehyde contents indicate that oxidation of the cellulose has occurred during the cooking and bleaching operations.

A plot of aldehyde or carboxyl versus 1/D.P. reflects little correlation of the aldehyde or carboxyl values to 1/D.P., showing that most of the aldehyde and carboxyl are not due to end groups. A plot of aldehyde plus carboxyl against 1/D.P. showed similar scatter. A fair correlation between aldehyde and carboxyl is shown in Fig. 1.

Table I. Aldehyde, Carboxyl, Pentosan and D.P. Data on the ICCA "Standard" Pulps[a]

Pulp no.	*Description of pulp*	*Aldehyde, millimole/g.*	*Carboxyl, millimole/g.*	*Pentosans,*[b] *%*	D.P.
1	Cotton-linters—acetate grade	0.0050 ± 0.0001	0.0050 ± 0.0001	0.49 ± 0.00	1720 ± 14
2	Sulphite pulp—acetate grade	0.0067 ± 0.0002	0.0162 ± 0.0001	0.98 ± 0.00	1310 ± 7
3	Prehydrolyzed sulphate pulp—tire-cord grade	0.0072 ± 0.0002	0.0148 ± 0.0002	0.83 ± 0.00	820 ± 14
4	Sulphite pulp—rayon grade	0.0124 ± 0.0001	0.0204 ± 0.0004	1.95 ± 0.01	940 ± 7
5	Sulphite pulp—cellophane grade	0.0109 ± 0.0001	0.0294 ± 0.0008	1.23 ± 0.00	660 ± 7
6	Sulphite pulp, birch—rayon grade	0.0167 ± 0.0001	0.0442 ± 0.0016	4.15 ± 0.03	820 ± 7
7	Sulphite pulp—paper grade	0.0124 ± 0.0001	0.0553 ± 0.0030	4.59 ± 0.06	1250 ± 15
8	Sulphite pulp—greaseproof grade	0.0275 ± 0.0001	0.0726 ± 0.0047	4.99 ± 0.03	1240 ± 7

[a] Standard pulps and description per Report of Interim Meeting of Executive Subcommittee II of ASTM D-23, Feb. 21, 1957. Pulps 1–5 obtained October, 1957, from Buckeye Cellulose Corp., Memphis, Tenn., and analyzed March, 1958. Pulps 6–8 obtained October, 1957, from Miss Karin Wilson, Uddeholms Aktiebolag, Skoghallsverken, Skoghall, Sweden, and analyzed March, 1958.
[b] The pentosans values were determined by B. W. Forshee of the Paper Section, National Bureau of Standards.

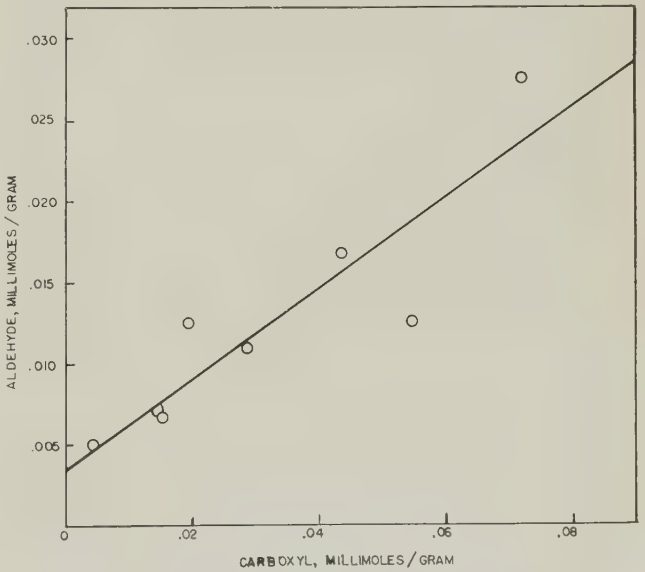

Fig. 1. Correlation between aldehyde and carboxyl contents of ICCA pulps

WILLIAM L. MORROW, Chemist, National Bureau of Standards, Washington 25, D. C.

The data reported in this paper are given only to assist in characterizing the ICCA pulps. The development of appropriate data on the precision of various methods by interlaboratory testing, using these pulps, is within the domain of the proper committee functioning under ACS, ASTM, TAPPI, or ICCA.

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Received Nov. 21, 1958.

Mechanism of Retention of Wet-Strength Resins*

I. Kinetic Studies of Melamine Resin Adsorption

EDWARD F. THODE, JOHN W. SWANSON, SHELDON F. KURATH, and GERALD R. HOFFMAN

As a first stage in a program of study into the physicochemical mechanism of adsorption of wet-strength resins on cellulose, rate studies have been made with melamine-formaldehyde resin. The conditions of the experiments were chosen so that the results might serve as a point of reference for other studies. The reactions were carried out at high dilution (0.01% consistency), with no foreign electrolyte present, and with beaten sulphite pulp from which the fines had been removed. Pulps from three beater intervals were used, and their external specific surface and swollen specific volume were measured. The increase in reaction rate with temperature indicated an activation energy of 5600 calories per mole for the particular pulp used. The increase in reaction rate with degree of beating of the pulp is, by preliminary indication, more closely related to the increase of swollen volume on beating than it is to the increase in external specific surface. By reference to previous literature, a hypothesis is advanced to explain the effect of dissolved salts in speeding the take-up of resin by wood pulp.

Insight into the mechanism of wet-strength production in paper has been sought through studies of the adsorption of the resin, the cure characteristics of the resin, and certain of the physicochemical properties of the system cellulose-resin-water. The very rapid take-up of resin on cellulose fiber at normal fiber consistencies and with the usual salts present has blocked attempts at kinetic (rate of adsorption) and equilibrium studies. For example, Gruntfest, Young, and Moser (*1*) report that as little as 6 sec. contact time of resin with pulp at 0.05% consistency produces wet strength as great as that resulting from 5 min. contact time.

On the one hand, Steenberg (*2*) has asserted that the extremely rapid reaction is "irreversible." This writer has deplored the presentation of adsorption isotherms. On the other hand, there is reason to believe that the reaction is merely one with an equilibrium far to the right, as in direct dyeing.

Since such physicochemical phenomena as the effect of anions on melamine resin retention, reported by Maxwell and Reynolds (*3*), presumably operate by changing the activation energy of the adsorption reaction, it was thought that a base-line study of the kinetics and thermodynamics of the cellulose-resin reaction was in order.

It was the object of the present investigation to determine the rate of adsorption of melamine acid colloid on wood cellulose at various temperatures, acidities, and fiber surface areas and at very low consistency. The complicating effects of fiber fines and of foreign electrolytes were to be avoided so that the data obtained might be useful as a reference point for future studies of such effects. It was a further object of the investigation to employ the data obtained for computation of such basic thermodynamic functions as the activation energy of the adsorption reaction. While the study of urea resins as well as melamine was an objective of the over-all project, the phase of the work here reported was limited solely to melamine-formaldehyde resin.

EXPERIMENTAL PROCEDURE

Fiber Preparation

In preparing fiber for the adsorption experiments, dry lap of western coniferous sulphite pulp (Weyerhaeuser) was torn up, soaked 4 hr., and beaten in a Valley beater. The beaten pulp was then processed on a Bauer-McNett classifier employing only the 20 and 150-mesh screens, and the fibers collected on both these screens were recombined. By this procedure, the fines which could cause variation in adsorption results were effectively removed. Table I summarizes essential information on the three sets of fiber samples employed. All the pulp required for a given set of runs was prepared at once, the various subbatches combined, pressed to 25% consistency and stored at 42°F. in the presence of formaldehyde.

Wet-Strength Resin

A commercial trimethylolmelamine low polymer (Parez 607) was dispersed in dilute hydrochloric acid solution according to the manufacturer's instructions, aged, then stored at 42°F. at 2 to 3% concentration. The stock solution was diluted with 9 volumes of deionized water immediately before addition to the pulp slurry. Resin concentration was verified by nitrogen analysis.

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* This has been a project of the Wet Strength and Fiber Interbonding Committee, and was supported by TAPPI Research Grant No. 101.

Table I. Characteristics of Pulp Samples

Set	*Beating time, min.*	*Filtration resistance at 30 cm. Hg, R × 10⁸ cm./g.*	*External specific surface, cm.²/g.*	*Swollen specific volume, cc./g.*
A	60	1.15	13,000	2.22
B	30	0.462	8,260	2.05
C	0	0.214	5,250	1.38

Resin Precipitation

The fiber taken from storage was thoroughly dispersed at 0.5% consistency, then diluted to 0.01% with deionized water. For all runs, pulp from lot A (the more highly beaten pulp) was used except for two sets of runs in which surface area was the desired variable. Deionized water was charged to an isolated storage tank for each run so that every point on a given isotherm was prepared from the same batch of water. At the beginning of the specified period of contact, the resin solution was added to the diluted pulp slurry with rapid but not violent stirring; this stirring was continued to within 5 sec. of the end of the period of contact, at which time the stirrer was removed and the slurry poured into a Valley sheet mold. Since the object of forming the sheets was solely that of recovering the fiber for analysis, and since there were no fines present to slow up the sheet formation, it was possible to begin drainage from the leg of the handsheet machine as soon as the stock began to enter the deckle box. The entire operation of separating the resin-treated fibers from the white water thus took but a few seconds, permitting very precise control of contact time. In regular runs, the contact times used were 30, 60, 150, and 300 sec.; temperatures of 5, 25, 45, and 65°C. were selected for the isotherms. Extended contact times of 1 and 2 hr. were also tried in a few cases. Five per cent, by weight, of resin was applied on the pulp in most cases; 2% in some others. The pH was 7.0 (pH of the deionized water) for most of the runs, but some data were obtained at pH 4.5. In this case, dilute hydrochloric acid was used to adjust the acidity of the deionized water to the desired level.

Analysis

The fibers which had been resin treated and the stock solution of melamine resin colloid were analyzed for organic nitrogen. The technique used was the Institute of Paper Chemistry semimicro Kjeldahl analysis. This method incorporates improvements of various workers

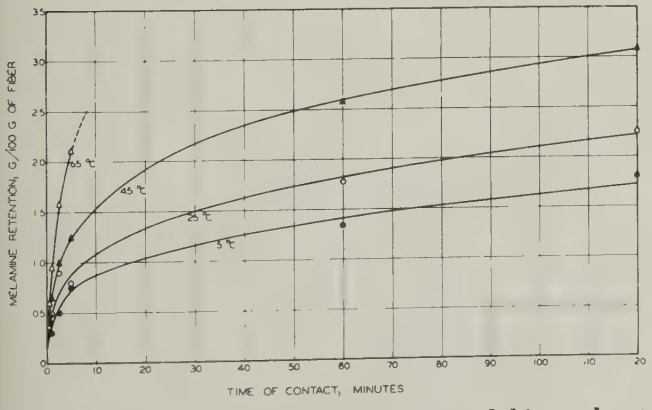

Fig. 1. Melamine retention on beaten sulphite pulp at various temperatures as a function of time. Consistency, 0.01% melamine added, 5.0 g./100 g. fiber, pH 7.0

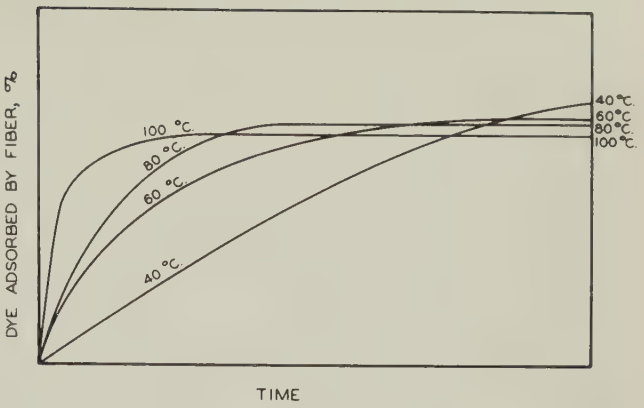

Fig. 2. Idealized curves for retention of dye colloid on cellulose, time axis extending to equilibrium (reference 6a)

beginning with Henwood and Garey (*4*) and differs from the common macromethod of TAPPI Standard T 418 m-50 (*5*) in the following important particulars: mercury is omitted, only the "Hengar" selenium catalyst granules being used; the absorbing acid is boric; and the indicator is a commercially prepared mixture known as M-AlkaVer.

RESULTS

The original data obtained in this investigation are summarized in Table II. Isotherms for 0.5% melamine addition at pH 7.0 are shown in Fig. 1. It may be seen from this figure that both the initial rate of adsorption and the total amount adsorbed after a long period of time, such as an hour, are directly related to the temperature of adsorption. The increase in rate of reaction with temperature is just about as one would expect, but from the data here shown, it is not clear what relative positions the curves would occupy at equilibrium. For the normal adsorption reaction such as that of dyeing cellulose fiber with direct dye, the adsorption-time isotherms cross one another as equilibrium is approached so that the maximum equilibrium adsorption is obtained at the lowest temperature. This situation is graphically illustrated for a typical dye in Fig. 2, taken from the work of Vickerstaff (*6a*). This usual condition for adsorption indicates an exothermic (heat-producing) reaction. In the present case for melamine-formaldehyde resin, it is impossible to tell whether or not the isotherms will cross before reaching equilibrium.

Energy of Activation

In order to thermodynamically evaluate the data, it is desirable to establish or assume the kinetic order of the reaction of melamine resin colloid with cellulose fiber. If we represent the concentration of resin in the solution and on the fiber surface both in terms of per cent by weight of resin based on the weight of fiber (permissible in this case because a constant, very low consistency was used), then

$$\frac{-dC}{d\theta} = k_1 C = k_1(C_0 - C_f) \qquad (1)$$

if the reaction is kinetically of the first order with respect to melamine concentration, and

$$\frac{-dC}{d\theta} = k_2 C^2 = k_2(C_0 - C_f)^2 \qquad (2)$$

if the reaction is kinetically of the second order with

Table II. Summary of Results, Melamine Resin, Adsorption-Time Isotherms

	5°C. Found N_2, %	5°C. Adsorbed resin, %	25°C. Found N_2, %	25°C. Adsorbed resin, %	45°C. Found N_2, %	45°C. Adsorbed resin, %	65°C. Found N_2, %	65°C. Adsorbed resin, %
Addition 5%, pH 7								
Sample A								
30 sec.	0.16	0.40	0.15	0.37	0.20	0.50	0.24	0.60
60 sec.	0.12	0.30	0.20	0.50	0.26	0.65	0.38	0.95
150 sec.	0.20	0.50	0.36	0.90	0.40	1.00	0.64	1.59
300 sec.	0.30	0.75	0.32	0.80	0.50	1.25	0.85	2.11
3600 sec.	0.54	1.34	0.76	1.87	1.04	2.59	...	...
7200 sec.	0.72	1.80	0.90	2.25	1.23	3.08	...	...
Sample B								
30 sec.			0.09	0.23				
60 sec.			0.12	0.30				
150 sec.			0.20	0.50				
300 sec.			0.29	0.73				
Sample C								
30 sec.			0.08	0.20				
60 sec.			0.10	0.25				
150 sec.			0.18	0.45				
300 sec.			0.22	0.55				
Addition 2%, pH 7, Sample A								
30 sec.	0.08	0.20	0.09	0.23	0.14	0.35	0.19	0.47
60 sec.	0.12	0.30	0.12	0.30	0.16	0.40	0.20	0.50
150 sec.	0.17	0.42	0.20	0.50	0.24	0.60	0.28	0.70
300 sec.	0.22	0.65	0.27	0.67	0.35	0.87	...	...
Addition 5%, pH 4.5, Sample A								
30 sec.	0.08	0.20	0.08	0.20	0.18	0.45	0.24	0.60
60 sec.	0.14	0.35	0.18	0.45	0.26	0.65	0.32	0.80
150 sec.	0.16	0.40	0.27	0.67	0.41	1.02	0.50	1.25
300 sec.	0.22	0.55	0.35	0.87	0.52	1.29	0.77	1.92

respect to melamine concentration at constant fiber consistency. In these equations, k_1 and k_2 are the first and second-order rate constants, respectively, $-dC/d\theta$ is the rate of disappearance of melamine colloid from solution, C is the concentration of melamine at any time, C_0 is the initial melamine concentration, and C_f is the amount of melamine adsorbed on the fibers at any time.

Integration between limits of the above two equations yields

$$k_1(\theta_2 - \theta_1) = \ln \frac{(C_0 - C_{f1})}{(C_0 - C_{f2})} \qquad (3)$$

for first order, and

$$k_2(\theta_2 - \theta_1) = \frac{1}{(C_0 - C_{f2})} - \frac{1}{(C_0 - C_{f1})} \qquad (4)$$

for second order. If the reaction is kinetically of the first order, equation (3) indicates that the data for any actual experiment should produce a straight line if time is plotted as a function of the natural logarithm of resin concentration remaining in the solution. Also, since the rate constant has the dimensions of inverse time only, any stoichiometrically consistent set of concentration units may be employed without affecting the magnitude of k_1. On the other hand, if the reaction is kinetically of the second order, a straight line should be produced from a graph of time as a function of the reciprocal of resin concentration. In this case, the rate constant will have a numerical value depending on the concentration units employed.

The plots described above were made for the data of this investigation and the plots indicated that the reaction was definitely not of the second order and was probably not of the first order. However, in the region of 30 to 300 sec. time, most of the isotherms came fairly close to the semilogarithmic straight line called for by the kinetic first order. It was felt a reasonable view to assume that the first order mechanism could be used for the purpose of computation.

After testing the *raw* data for order of reaction, the data were smoothed by plotting amounts of resin adsorbed as a function of the logarithm of time, a procedure suggested by Vickerstaff (*6b*). From the smoothed data at reaction times of 60 and 300 sec., values of k_1 were computed at 5, 25, 45, and 65°C. for the adsorption at pH 7 and also at pH 4.5, from solutions originally containing 5% melamine resin colloid based on the fiber. Application of the integrated form of the Arrhenius equation,

$$\ln k = -E/RT + \text{const.} \qquad (5)$$

to the data for variation in rate constant with temperature should produce a straight line with slope, E/R. As may be seen from Fig. 3, such a plot does show very good adherence of the data to a straight line. The data for pH 4.5 scatter less than those for pH 7. The data at both pH levels are equally well represented by the arbitrary straight line indicated on the figure. Calculation of an energy of activation from the data gives a value of 5600 cal. per mole for these conditions of very low fiber consistency and consequent very low melamine colloid concentration. This figure may be compared with a value of some 14,000 cal. per mole determined for some dyestuffs (*6c*) and one of 4400 cal. per mole for a modified locust bean gum (*7*). Such comparisons indicate that the takeup of melamine resin on cellulose in solution occurs with comparative ease and that primarily a physical process is involved. The rate limiting step may be physical adsorption, but, in this range of activation energy, it is more likely to be a diffusional

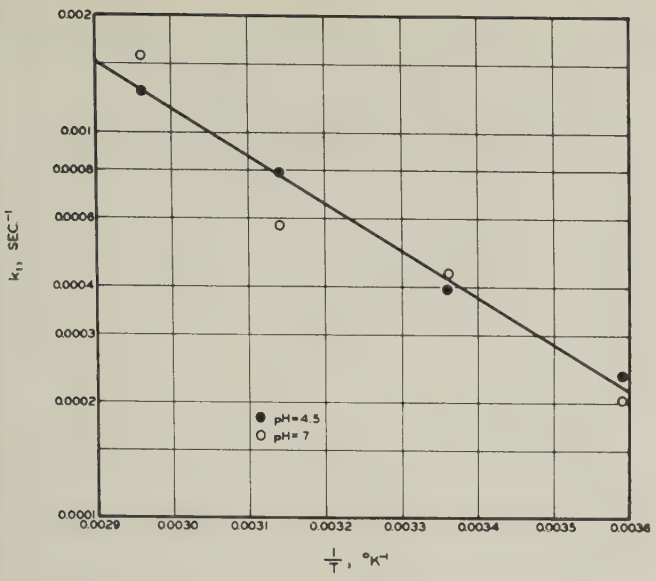

Fig. 3. Variation of rate constant with temperature. Adsorption of melamine colloid on sulphite pulp

transport step. For example, in the gum sorption study recently reported by Russo (*7*), it was definitely established that a diffusion process played a major role in controlling the initial rate of reaction. The high dependence of melamine sorption rate on solution concentration suggests that such is true in this case too.

DISCUSSION

The interpretation of the effect of higher concentration of salts and higher concentration of reactants in greatly speeding the reaction may proceed from either of two points of view, both of which ultimately refer to the same phenomena. Both approaches assume that the reaction proceeds so much more rapidly at higher concentrations because of actual increase in the rate constant, not merely because of mass action effects.

The rate constant at any concentration, k, is related to the rate constant at infinite dilution, k_0, by the Brønsted-Bjerrum equation,

$$\ln k = \ln k_0 + \ln f_a f_b / f_* \qquad (6)$$

for a bimolecular reaction where f_a and f_b are the activity coefficients of the reactants and f_* is the activity coefficient of the activated complex. The term, $f_a f_b / f_*$, has been called the kinetic activity factor. If the reactants are ionized, the kinetic activity factor may be related to the valence of the ions and to the ionic strength of the solution, so that the Brønsted-Bjerrum equation is modified as follows:

$$\ln k = \ln k_0 - 0.5\,(z_a^2 + z_b^2 - z_*^2)\,\sqrt{\mu} \qquad (7)$$

where z_a, z_b, and z_* represent the charges of the reactants and complex, and μ is the ionic strength. In a normal bimolecular reaction involving simple ions, $z_*^2 = z_a^2 + 2z_a z_b + z_b^2$ so that the rate constant will increase with increase in ionic strength if the product, $z_a z_b$, is positive and will decrease if it is negative. If, however, one of the reactants is uncharged, the product is zero, and the rate constant is not affected by ionic strength in dilute solution. While cellulose is not ionized in a formal sense, it does carry a charge which is known to affect reactions in solution. With information presently at hand, it is not possible formally to evaluate equation (7).

To move into the realm of informed speculation, however, we can infer that if the charge relationship is such that the rate constant increases with ionic strength, a good explanation may be had for the salt effect observed by Maxwell and Reynolds (*3*). These authors show that retention of melamine hydrocolloid is at first improved by addition of ionized salts but later drops off. The later drop-off is a matter of coagulation of the colloid by the salt and is of no interest in the present context. The initial rapid rise would seem to imply an acceleration of the rate constant, quite understandable if the rate constant increases with increasing ionic strength. Since ionic strength depends on the square of the valence of the ionic species present, the very considerable effect of polyvalent ions noted by Maxwell and Reynolds is consonant with theory.

Another view of this salt effect may be seen in the following quotation: ". . .the activation energy of adsorption. . .with charged dye ions should increase with the surface charge of the fiber and with the charge on the dye itself. By the addition of strong electrolyte to the aqueous solution, the charge on the surface is made less effective, either by actual reduction in the charge on the fiber or by a screening of the charged surface towards approaching ions by a swamping number of other ions. In either case, the effect upon the dye ion is the same, namely that it can approach more closely to the surface before electrical repulsion becomes effective. It follows, therefore, that the activation energy of the dyeing process will be reduced and dyeing facilitated by the addition of salt" (*6d*).

The view expressed above does not specifically apply to the case of melamine acid colloid and cellulose fiber because the reactants are of the opposite charge in this case, not of the same charge as in the case of direct dye ions and pulp fibers. However, it still holds that the surface would be screened or modified by the presence of foreign ions and the activation energy thereby affected.

If a diffusional transport process controls, the views of an ionic screen expressed above may still apply. The barrier to diffusion may be a matter of molecular

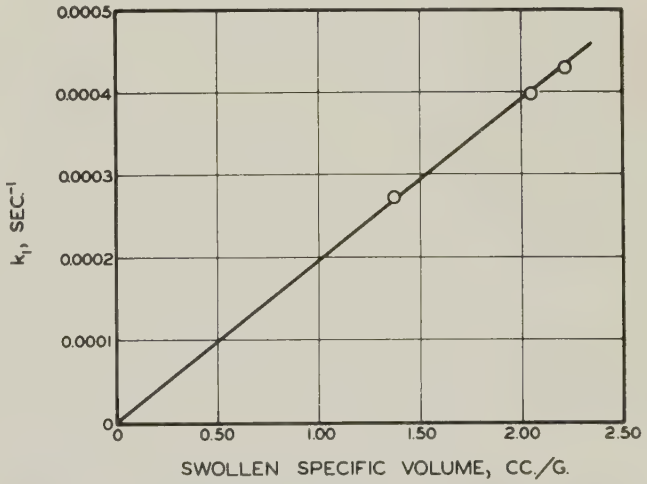

Fig. 4. Variation of rate constant with swollen specific volume of pulp. Adsorption of melamine colloid on sulphite pulp

collisions only but can involve ionic repulsions or attractions also.

In summary of this part of the discussion, it should be emphasized that the rate constants and energy of activation here reported are mainly useful as a baseline for comparing effects at normal papermaking concentrations of the reactants and foreign salts present. The conditions here used are very nearly limiting as to slowness of reaction.

With regard to the true order of the reaction, it seems reasonable to believe that the over-all order of the initial reaction is not first order as was roughly approximated in these experiments using a constant fiber concentration. If the initial rate-controlling reaction is some physical process, or if simultaneous and/or sequential reactions take place, order of reaction has no physical meaning. However, there seems little doubt from the results of these and earlier experiments that the rate of the adsorption reaction is affected both by the concentration of the resin and by the concentration of cellulose.

In this connection, it is of interest to note the results of the single experiment on varying the surface area of the pulp used for the melamine adsorption as shown in Table III and in Figs. 4 and 5.

Table III. Melamine Take-up on Unbeaten and Beaten Pulp

	External sp. surface	*Swollen sp. vol.*	k_1	*Resin take-up, 5 min.*
Unbeaten	5,250	1.38	0.000272	0.55
Beaten	8,260	2.05	0.000399	0.73
Beaten	13,000	2.22	0.000431	0.80

With due regard for the dangers of generalizing from a small amount of data, it is fair to state that the preliminary indications are that the rate of take-up of melamine is not so much affected by the external specific surface (hydrodynamic) as by the swollen specific volume of the fiber. Several explanations of this behavior are possible: (1) the surface exposed on beating may be chemically different from that "originally present"; (2) the hydrodynamic surface may not be very close to, or proportional to, the surface involved in melamine resin adsorption; or (3) the reaction is not so much that of a plane surface as that of a gel about which a membrane equilibrium exists. It is, of course, not possible from the limited present data to determine which, if any, of the above explanations are valid. It is seriously recommended that considerable additional data be obtained on systems of varying surface area and swollen volume to try to get at the heart of the matter. In particular, attempts should be made to measure and control all ionizable substances in the system with a view to obtaining data useful in calculating a possible Donnan membrane equilibrium.

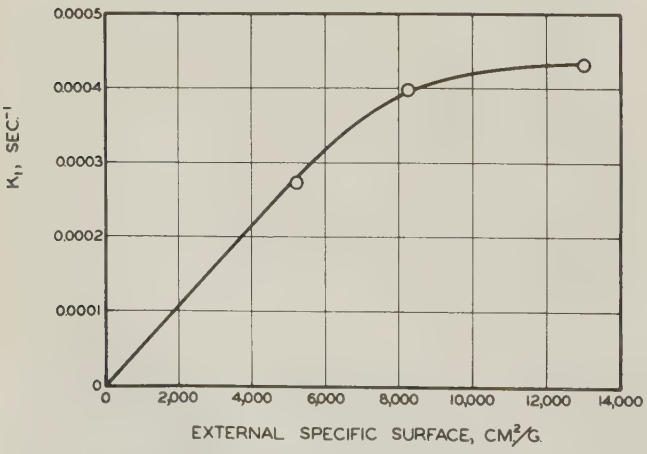

Fig. 5. Variation of rate constant with external specific surface of pulp. Adsorption of melamine colloid on sulphite pulp

Heat of Adsorption

As mentioned in the results section, the data for the isotherms in Fig. 1 do not extend over a long enough time to permit calculation, or estimation, of the equilibrium adsorptions. No calculation of the heat of adsorption is possible. On a preliminary basis, attempts were made to determine the heat of adsorption directly, by measuring the temperature change of a 1% consistency fiber slurry upon addition of 5% melamine colloid based on the weight of the fiber. This was done in several ways under conditions minimizing external heat effects. Precision was quite poor, but all tests indicated that the reaction was slightly endothermic. While this situation is rather unusual for an adsorption reaction, it is not impossible, particularly where the adsorbate is a polymer. Also, an endothermic reaction would be consistent with the trend of the curves in Fig. 1. The upper isotherms have passed or approached 50% exhaustion with no indication that they are certain to cross. It is thought that this matter can readily be examined in a later portion of this investigation wherein studies would be made at somewhat higher consistencies, since equilibrium would be approached more rapidly in those cases.

CONCLUSIONS

The initial rate of adsorption of melamine acid colloid on beaten sulphite pulp may be approximated by a first-order mechanism at constant fiber consistency. At 0.01% consistency, the energy of activation was 5600 cal. per mole for the pulp used.

Beating of the pulp greatly affected the initial rate of reaction. It is not known whether or not the energy of activation is affected; however, preliminary indications show that the specific volume change of the pulp on beating is more closely tied to the change in reaction rate than is the increase in external specific surface.

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Mechanism of Retention of Wet-Strength Resins*

II. *Rate Studies on the Adsorption of Urea-Formaldehyde Resin*

SHELDON F. KURATH, CHUNG YING CHU, and JOHN W. SWANSON

The adsorption of urea-formaldehyde wet-strength resin is postulated to take place in two steps—diffusion and adsorption. With the information on hand, it is impossible to decide which of the two steps is rate controlling or if both play an important role in the adsorption process. Microscopic examination of resin-treated fibers indicates that the resin is uniformly distributed on the fiber surface. A study of microtomed fibers indicated that no resin was located within the body of the fibers. Resin retention by filtration effects is found to be unlikely. Rate studies have been carried out on the adsorption of urea-formaldehyde wet-strength resin. The initial rate of adsorption is given by the empirical equation, $r = kR_{so}^{1.4}$ where, r is the rate of resin adsorption, R_s is the initial concentration of resin in solution, and k is a constant not necessarily of chemical kinetic significance. Rather severe restrictions are placed on the use of this equation. An activation energy of 5200 calories per mole was found for the temperature dependence of the rate process. This was found to agree well with that observed for the adsorption of melamine-formaldehyde resins. A similar activation energy can be computed by assuming the rate of adsorption to be diffusion controlled.

THIS is progress report two on Project 1964 established in cooperation with the Technical Association of the Pulp and Paper Industry for the purpose of investigating the mechanism by which wet-strength resins are taken up by fibers.

The adsorption of wet-strength resin on pulp in a water-pulp-resin system can be postulated to take place in a series of steps. For a heterogeneous system such as this, the following steps would seem to be reasonable:

$$R_s \rightarrow R_{fs} \quad (1)$$

$$R_{fs} \rightarrow R_{fa} \quad (2)$$

$$R_{fa} \rightarrow R_{fs} \quad (3)$$

$$R_{fs} \rightarrow R_s \quad (4)$$

$$R_{fa} \rightarrow R_{fi} \quad (5)$$

First, the resin in solution R_s must be transported from solution to the surface of the fiber R_{fs}, step one. A thin fluid film is known to exist at the interface between the fiber and the moving solution. The transport step is assumed to take place across this film. The resin at the fiber surface is still assumed to be in solution. Once the resin is at the surface of the fiber it is free to adsorb on the fiber as R_{fa} according to step two. The reverse steps three and four are also possible. In addition, it might be postulated that the resin on the surface of the fiber is free to diffuse into the fiber interior R_{fi}, step five.

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* This has been a project of the Wet Strength and Fiber Interbonding Committee, and was supported by TAPPI Research Grants Nos. 101 and 117.

Step five has been eliminated on the basis of microscopic examination of the resin-treated fiber in which the resin was found to be confined to the fiber surface. This has been observed by other workers (*1*). A study of microtomed resin-treated fibers indicated that no resin was located within the body of the fiber. The reverse steps three and four were not important since all measurements were confined to the initial rate of adsorption. The discussion in the present report will be centered about steps one and two.

EXPERIMENTAL

Pulp Characteristics

The pulp used for these experiments was a Weyerhaeuser bleached pulp beaten to a Schopper-Riegler freeness of 750 ml. The pulp was processed on a Bauer-McNett classifier and only that portion collected between 20 and 150-mesh screens was retained. The external specific surface was 12,100 sq. cm. per g. and the swollen specific volume was 1.74 cc. per g. The pulp was dewatered to a 30% consistency, treated with dilute formaldehyde and stored in polyethylene bags at 42°C.

Urea-Formaldehyde Resin

The resin (Kymene S351) was a dried high molecular weight fraction of a cationic urea-formaldehyde resin which is marketed by the Hercules Powder Co. We are indebted to Gerald Keim for the present sample.

The dried resin was used to make up stock solutions at 2 to 3% solids content in dilute formic acid. The resin was stored for 3 or 4 days at a pH of 5.0 before use.

Adsorption-Time Experiments

In studying the amount of resin adsorbed on the fibers as a function of time, the following procedure was followed. The pulp was washed several times with deionized water, dispersed, and diluted to 0.01% consistency. The pH was adjusted to 4.5 and the resin solution was added. After predetermined contact times the slurry was poured into a Valley sheet mold to separate the fiber from the resin solution and thereby terminate the contact. The resin content of the stock solution and the treated pulp was determined by analysis for organic nitrogen as reported previously (*2*).

The Effect of Concentration on Adsorption Rate

The effect of concentration on any rate process is important since any proposed mechanism must not fail to explain the course of the rate process as a function of concentration. If a chemical kinetic interpretation is placed on the rate process, then the initial reaction rate can be used to evaluate the order of the chemical reaction. If a transport step is involved, the effect of

concentration can be interpreted as a change in diffusion coefficient or mobility. Experiments in this section are confined to the initial rate of resin adsorption. By doing this, the complications of reverse rate steps and changes in resin concentration are eliminated. Experiments were limited to contact times in the 15 to 300-sec. range and to resin concentrations of 0.001, 0.002, 0.005, 0.007, and 0.010 g.p.l. All experiments were carried out at 25°C. and a constant pH of 4.5. In addition, a constant pulp consistency of 0.01% was maintained throughout. The results are shown in Table I and Fig. 1. The initial adsorption rate was found to obey the empirical equation:

Table I. The Effect of Resin Concentration on the Rate of Adsorption[a]

Contact time, sec.	*Nitrogen on fibers, %*	*Resin on fibers, %*
	R_{so} = 0.001 g.p.l.	
120	0.010	0.040
150	0.010	0.040
180	0.013	0.048
225	0.015	0.056
275	0.022	0.081
300	0.029	0.110
	R_{so} = 0.002 g.p.l.	
60	0.012	0.044
75	0.024	0.089
90	0.017	0.063
120	0.015	0.056
150	0.019	0.070
180	0.031	0.120
225	0.038	0.140
275	0.043	0.160
300	0.047	0.170
	R_{so} = 0.005 g.p.l.	
15	0.010	0.037
30	0.022	0.081
45	0.029	0.110
60	0.033	0.120
75	0.048	0.180
90	0.050	0.180
120	0.052	0.190
150	0.064	0.240
180	0.075	0.290
225	0.090	0.330
275	0.100	0.370
300	0.100	0.370
	R_{so} = 0.007 g.p.l.	
15	0.022	0.081
30	0.036	0.133
45	0.043	0.160
60	0.054	0.200
75	0.068	0.250
90	0.078	0.290
120	0.090	0.330
150	0.100	0.370
180	0.120	0.440
225	0.140	0.520
275	0.160	0.590
300	0.150	0.560
	R_{so} = 0.010 g.p.l.	
15	0.036	0.130
30	0.052	0.190
45	0.068	0.250
60	0.080	0.300
75	0.090	0.330
90	0.100	0.370
120	0.110	0.410
150	0.130	0.481
180	0.140	0.520
225	0.150	0.560
270	0.160	0.590
300	0.200	0.740

[a] R_{so} is initial concentration of resin in solution; all pulp used in these experiments was beaten to a Schopper-Riegler freeness of 750; all experiments were carried out at 25°C. at a pH of 4.5 and at pulp consistency of 0.01% (0.1 g.p.l.).

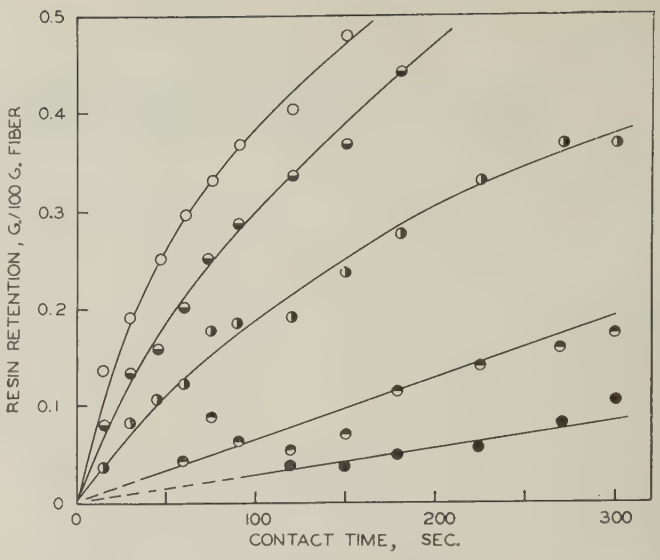

Fig. 1. Rate of urea-formaldehyde resin adsorption on beaten sulphite pulp

Initial resin concentration; 0.001 g.p.l. (black circles), 0.002 g.p.l. (top black), 0.005 g.p.l. (right black), 0.007 g.p.l. (bottom black), and 0.010 g.p.l. (open circles). Consistency is 0.01%, pH is 4.5, and temperature is 25°C.

$$r = kR_{so}^{1.4} \qquad (6)$$

where

r = rate of resin adsorption on the fiber, g. per 100 g. fiber per sec. at a consistency of 0.01%.
R_{so} = initial concentration of resin in solution, g.p.l. or g. per 1000 g. H_2O.
k = 5.1 ± 1.0 sec.$^{-1}$.

This equation is strictly limited to the resin concentration range, R_{so}, from 0.001 to 0.010 g.p.l. and to a single pulp consistency of 0.01%. A chemical kinetic interpretation of equation (6) will not be made since, as we shall show, the rate may be controlled by diffusion and may have no chemical kinetic significance whatever.

Effect of Temperature on Adsorption Rate

The effect of temperature on the rate of adsorption was investigated using an initial resin concentration of R_{so}, 0.005 g.p.l., and the pulp beaten to a Schopper-Riegler freeness of 750 ml. The pulp consistency was 0.01% and a pH of 4.5 was maintained throughout. The results are given in Table II and in Fig. 2.

If a kinetic interpretation is placed on equation (6), then the constant k may be interpreted as a rate constant and the Arrhenius equation may be used in the form:

$$\ln k = -\frac{E}{RT} + \text{constant} \qquad (7)$$

where

E = energy of activation.
R = gas constant.

According to this equation, a plot of ln k versus $1/T$ should yield a straight line of slope $-E/R$. If the constant k is a diffusion constant, the same equation can be used to compute an activation energy for diffusion, see equation (10).

A plot of equation (7) is shown in Fig. 3 and was

used to compute an activation energy of 5200 ± 1000 cal. per mole for the rate process. This compares favorably with the value of 5600 cal. per mole that is observed for the adsorption of melamine-formaldehyde resins (*2*).

Microscopic Examination of Fibers

It has been suggested (*1*) that urea-formaldehyde and melamine-formaldehyde resins are retained mainly as a result of a filtration effect of fibers. This conclusion has important bearing on the present work and it was decided to undertake microscopic examination of the fibers.

Samples of resin-treated fiber were stained with Acid Fuchsine Red (Fisher Scientific Co.) and examined under the microscope. The resin was found to be uniformly distributed on the fiber surface. Microtomed samples indicated that no resin was located within the body of the fiber. Small resinous particles were also observed but these were traced to natural resins in the fiber and to impurities in the deionized water supply. Most of these could be eliminated through the use of distilled water and centrifugation.

In a second set of experiments, the resin-treated fiber was treated with C stain prepared in this laboratory. In these experiments the resin was found to exist on the fiber surface in small droplet-like particles. This is probably due to the high salt concentration in the staining solution.

Although considerably more work is required in terms of microscopic examination, the feeling is that the resin is uniformly distributed on the fiber and that when resin particles are observed they may be traced to foreign contamination or to an alteration of the resin by the specific staining procedure.

Table II. The Effect of Temperature on the Rate of Adsorption[a]

Contact time, sec.	*Nitrogen on fibers, %*	*Resin on fibers, %*
	Temperature = 5°C.	
15	0.015	0.056
30	0.027	0.100
45	0.032	0.119
60	0.037	0.137
75	0.038	0.141
90	0.043	0.159
120	0.058	0.215
150	0.060	0.222
180	0.076	0.281
225	0.078	0.289
275	0.090	0.333
300	0.099	0.367
	Temperature = 35°C.	
15	0.030	0.111
30	0.039	0.144
45	0.040	0.148
60	0.057	0.211
75	0.060	0.222
90	0.072	0.267
120	0.090	0.333
150	0.090	0.333
180	0.110	0.407
225	0.120	0.444
275	0.120	0.444
300	0.130	0.481
	Temperature = 45°C.	
15	0.032	0.119
30	0.055	0.204
45	0.057	0.211
60	0.074	0.274
75	0.076	0.281
90	0.080	0.296
120	0.100	0.370
150	0.110	0.407
180	0.120	0.444
225	0.130	0.481
275	0.140	0.519
300	0.140	0.519
	Temperature = 65°C.	
15	0.034	0.126
30	0.053	0.196
45	0.080	0.296
60	0.090	0.333
...	...	...
90	0.100	0.370
120	0.110	0.407
150	0.110	0.407
180	0.130	0.481
225	0.130	0.481
275	0.140	0.519
300	0.150	0.556

[a] All pulp used in these experiments was beaten to a Schopper-Riegler freeness of 750; all experiments were carried out at a pH of 4.5 and at pulp consistency of 0.01% (0.1 g.p.l.).

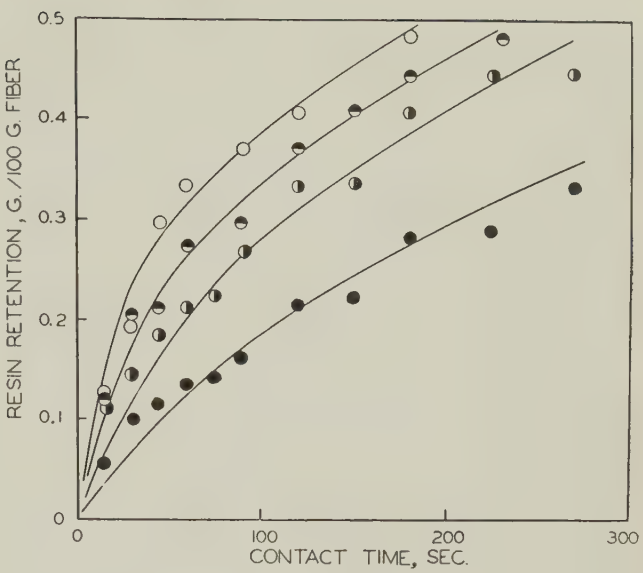

Fig. 2. Effect of temperature on the rate of urea-formaldehyde resin adsorption

Beaten sulphite pulp; consistency 0.01%, initial resin concentration, 0.005 g.p.l., pH of 4.5. Temperature: 5°C. (black circles), 35°C. (right black), 45°C. (top black), and 65°C. (open circles).

DISCUSSION

In the introduction, we postulated two possible steps, one and two, which might account for the rate of adsorption of wet-strength resin on pulp fibers. With the data on hand, we are unable to decide which of the two steps is rate controlling or if both play an important role in the adsorption process. We can, however, indicate that diffusion of the resin to the fiber surface is an important step and show that the activation energy that one can calculate, assuming diffusion to be a rate-controlling step, is similar to that which can be measured experimentally. We are unable to tell whether the effect of concentration on the rate process is indicative of a complex adsorption reaction or a diffusion process which is concentration dependent (i.e., a diffusion constant that is a function of concentration). According to our initial assumptions, step one involves the transport of the resin to the surface of the fiber. This can be formulated as a problem in diffusion. It is not a simple problem, however, since

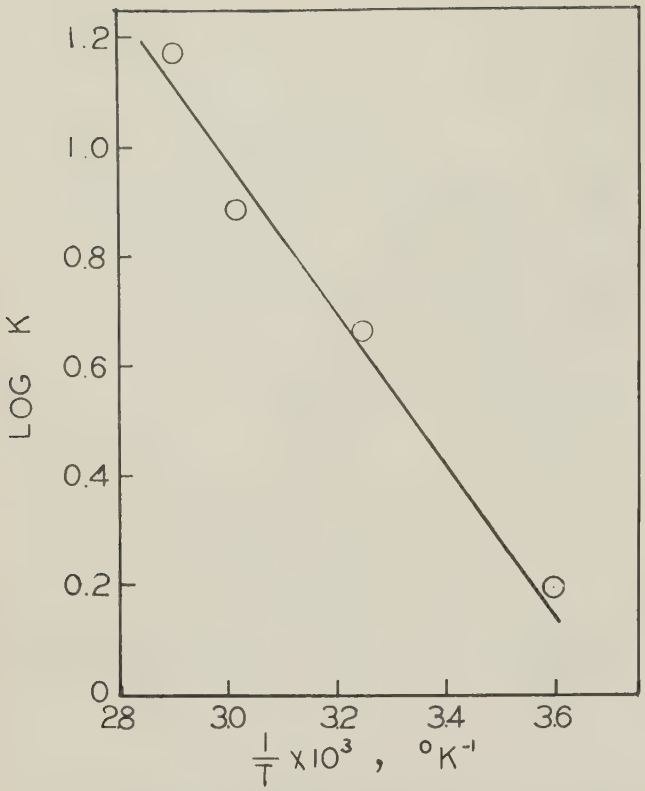

Fig. 3. Variation of rate constant with temperature adsorption of urea-formaldehyde resin on sulphite pulp

both resin and fiber are known to be charged. This means that the charged resin must diffuse in a potential field and is subject to forces that may be derived from the field. This is a special case in the theory of Brownian motion (*3*) and can be used to derive the following differential equation for the initial rate of unidirectional diffusion of resin to the surface of the fiber:

$$= -\frac{R_s}{\beta}\frac{\partial U(x,t)}{\partial x} - D\frac{\partial R_s}{\partial x} \qquad (8)$$

where

j = diffusion current in the x direction, g. per sec. per sq. cm.
D = diffusion coefficient.
β = a friction coefficient.
$U(x, t)$ = potential field about the fiber due to its charge.
R_s = concentration of resin in solution.

The second reaction step involves the adsorption reaction and, for lack of sufficient information, it will be assumed to be of the form:

$$r_{fs} = k_2 R_{sf} \qquad (9)$$

where

r_{fs} = the rate of resin adsorption on the fiber.
R_{sf} = concentration of the resin at the fiber surface.
k_2 = the rate constant for the adsorption reaction.

Strictly speaking we are unable to carry our analysis any further than the formulation of equations (8) and (9). The discussion can, however, be continued on a speculative basis and the results are not without interest. To do this, reaction two will be assumed to be so rapid that step one is rate controlling. In addition, the first term on the right hand side of equation (8) will be assumed to be considerably less than the second. Equation (8) then becomes simply Fick's first law of diffusion and the equation may be written in the form (*4*):

$$j_t = (DA_t/l)(R_s - R_{fs}) \qquad (10)$$

where

j_t = total diffusion current g. per sec.
R_s = concentration of resin in solution.
R_{fs} = concentration of resin in solution at the fiber surface.
l = equivalent film thickness.
A_t = total area of the fibers.

At zero time R_{fs} is zero and the initial diffusion current is simply proportional to the initial resin concentration R_{so}.

Eyring has shown that the diffusion constant may be written as (*5*):

$$D = A \exp -(E/RT) \qquad (11)$$

where

E = apparent activation energy.
A = a constant.
R = the gas constant.

For many aqueous systems (*6*) the diffusion constant follows the equation:

$$D_T = D_{To}\frac{\eta_{To}}{T_o}\frac{T}{\eta_T} \qquad (12)$$

where

D_T = diffusion constant at temperature T.
η_T = viscosity at a temperature T.
T_o refers to an arbitrary reference temperature.

Upon substituting equation (12) in equation (11) and by taking logs, the following equation is obtained.

$$\ln\frac{T}{\eta_T} = -\frac{E}{RT} + \ln A - \ln\frac{D_{To}\eta_{To}}{To} \qquad (13)$$

According to this equation, a plot of $\ln T/\eta T$ versus $1/T$ should yield a straight line with a slope of $-E/R$. Equation (13) was used to compute the apparent activation energy for a solute diffusing in water. Viscosity-temperature data were taken from the literature (*7*). Values for E of 4600 and 5100 cal. per mole. were obtained at 25 and 15°C., respectively, and compare quite well with the values of 5700 and 5200 cal. per mole obtained from rate studies on melamine-formaldehyde and urea-formaldehyde resins, respectively. This strongly suggests that the rate of resin retention is controlled by a diffusion process.

If this is the case, then by comparing equations (10) and (6) the diffusion coefficient can be written as:

$$D = \frac{1k}{A} R_{so}^{0.4} \qquad (14)$$

The variation of D with concentration is not uncommon for polymers and can be considered to be of the form (*8*):

$$D = \frac{kT(1 + d\ln\gamma/d\ln Rs)}{\beta}$$

where

k = Boltzman's constant.
γ = activity coefficient of the resin.
R_s = concentration of the resin.
β = a friction coefficient.

For the charged urea-formaldehyde system, β will

also depend on concentration. The main point is that the diffusion coefficient can increase with concentration.

FUTURE WORK

It is still necessary to decide which of the two postulated steps determine the rate of the adsorption process. This should be possible in the following manner. The diffusion step represented by equation (9) contains the equivalent film thickness. The thickness of the film will decrease as the relative velocity between the fiber and the solution increases. If diffusion is a rate-controlling step, then the rate of adsorption will increase with increase in the relative velocity. This can be conveniently tested by passing the resin solution through a fiber mat at various velocities and observing whether or not an increase in adsorption rate occurs. If the adsorption rate is diffusion controlled, then an independent measurement of the diffusion coefficient may be in order.

A detailed study on the effect of degree of beating has not yet been carried out. The limited number of experiments that have been done indicate that it is an extremely important variable.

Measurements taken at different pulp consistencies will become quite important if diffusion is established as a rate-controlling step since the rate may also depend upon consistency.

The effect of concentration of foreign ions has been found to be important in the past and should be studied in any future extension of this research program.

It is necessary to know more about the constitution of the resin itself before additional experiments can be designed.

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Anodic Protection of Alkaline Pulping Digesters

W. A. MUELLER

It is shown that anodic protection can be used in stationary alkaline pulping digesters when oxidized black liquor is used for make-up. However, when nonoxidized black liquor is used the application of anodic protection is advisable only in mixtures where the black liquor addition exceeds a minimum level. This study has been based on the measurement and analysis of polarization curves of steel under cooking conditions. The protection of a digester was investigated in a mill-scale experiment. For that purpose a steel cathode was suspended in the axis of the digester. A suitable reference electrode, involving a modification of an existing design, was developed for continuous measurement of protection under the high temperature and high pressure conditions in a digester. Potential-time curves were measured in the digester to determine the effect of the electrode current on the difference in potential between digester shell and liquor. The current required for anodic protection was measured in indirectly steamed cooks in various mixtures of white liquor and nonoxidized black liquor, and in directly steamed cooks in a one liquor mixture. In agreement with the theory it was found that the current required for passivation is markedly decreased by: (1) increasing the addition of black liquor, (2) changing from indirect to direct steaming, (3) replacing nonoxidized with oxidized black liquor, (4) decreasing the concentration of unhydrolyzed sodium sulphide, (5) increasing the degree of overscaling.

THE corrosion of alkaline pulping digesters has received considerable attention in recent years, and extensive efforts have been made to determine the causes. Various methods of protection have been developed and applied (*3*) such as lining with stainless steel, Inconel, and carbon steel; and cathodic protection. Also numerous suggestions as to digester design and filling practices have been made, particularly as a result of a Canadian field study (*1*).

These diversified approaches illustrate the variety of methods that can be used for corrosion protection. However, many mills continue to order steel digesters 2 in. thick, 1 in. being the allowance for loss by corrosion. Evidently there is still a need for an inexpensive and reliable method of corrosion protection.

Earlier laboratory experiments (*5*, *6*) indicated that anodic protection offered excellent possibilities. These experiments have now been extended to a mill digester, and have shown that a digester can be passivated, i.e., corrosion can be stopped by this technique. As will be outlined below, the liquor conditions during these experiments were probably the least favorable. They can be characterized by: (1) a low ratio of black to white liquor in the liquor mixture and (2) the use of nonoxidized black liquor for make-up. However, the ratio of black to white liquor is usually considerably higher in conventional cooks and black liquor can be oxidized. Oxidization of black liquor considerably improves the conditions for the application of anodic protection. Hence it can be concluded that anodic protection can be applied in any stationary alkaline pulping digester with a fraction of the current required in these first trials. The present paper presents a survey of the work that has led to these conclusions. Papers on a modified design of a calomel reference electrode developed for continuous use at elevated temperatures and pressures (*8*), and on the theory and methods evolved in electrochemi-

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Fig. 1(a). Photograph of steel electrodes taken during the measurement of a 10-point polarization curve

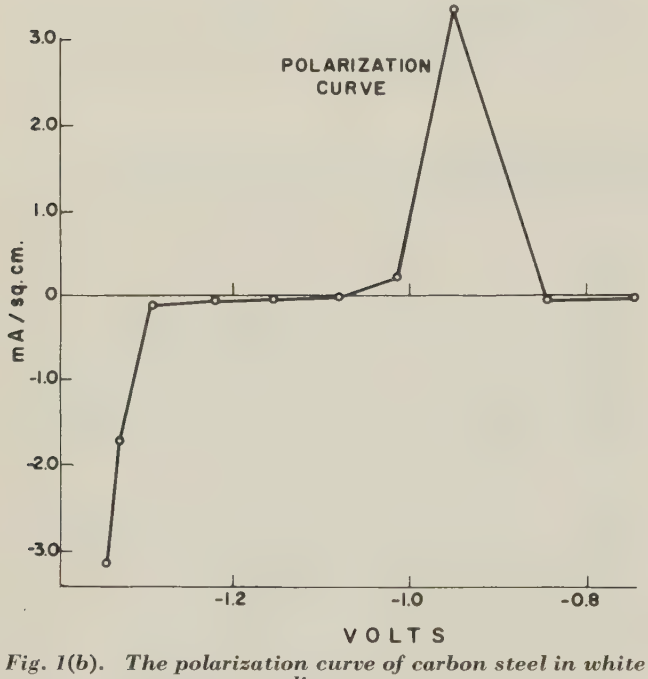

Fig. 1(b). The polarization curve of carbon steel in white liquor

cal studies of corrosion and anodic protection (7), are in preparation.

EXPERIMENTAL

Study of the Mechanism of Corrosion by Means of Polarization Curves

The present work stems from the observation that corrosion of iron in alkaline pulping liquors occurs only in a limited potential range. This may be illustrated by the following experiment: If a potential difference of 0.9 v. is applied to a series of nine resistors of 1 ohm each, the potential drop between succeeding resistors is 100 mv. These potentials are then applied to 10 steel electrodes which are immersed in clear white liquor. It will be observed, Fig. 1(a), that corrosion products are formed at only two, the 7th and 8th, if the most negative potential is taken as the first. Figure 1(b) shows the polarization curve of carbon steel in white liquor at 30°C. The polarization curve represents the current* at the surface of the steel electrodes as a function of the potential difference between the steel electrodes and the liquor. It is seen that the corrosion only occurs between −1.1 and −0.9 v., this narrow region being surrounded by the corrosion-free anodic and cathodic areas. This experiment suggests the possibility of two protective methods: Anodic protection, i.e., by shifting the potential to the anodic range (−0.9 v. or *less* negative values), and cathodic protection, i.e., by shifting the potential to the cathodic range (−1.1 v. or *more* negative values).

Under these conditions corrosion is an electrochemical phenomenon for it involves an exchange of electrical charges between the metal and the surrounding electrolyte. Thus, when iron corrodes in alkaline cooking liquors, positively charged Fe ions leave the iron as Fe^{2+} or Fe^{3+} ions and thereby form an electrical current. This process causes a deficiency of positive charges, as a surplus of negative charges accumulates at the iron surface. If this were the only reaction, the corrosion would be stopped. But simultaneously, a second type of reaction involving dissolved oxidizing substances occurs which brings about depolarization. This reaction removes negative charges from the electrode which produces an electrical current whose direction is opposite to that due to the formation of Fe ions. The depolarizing reaction then, causes the corrosion process to become continuous.

In the absence of external influences, the rates of these

* For the sake of simplicity the expression "current" is used instead of the more accurate expression "current density."

Fig. 2. Analysis of a schematic polarization curve of carbon steel in 60% white and 40% nonoxidized black liquor at 100°C.

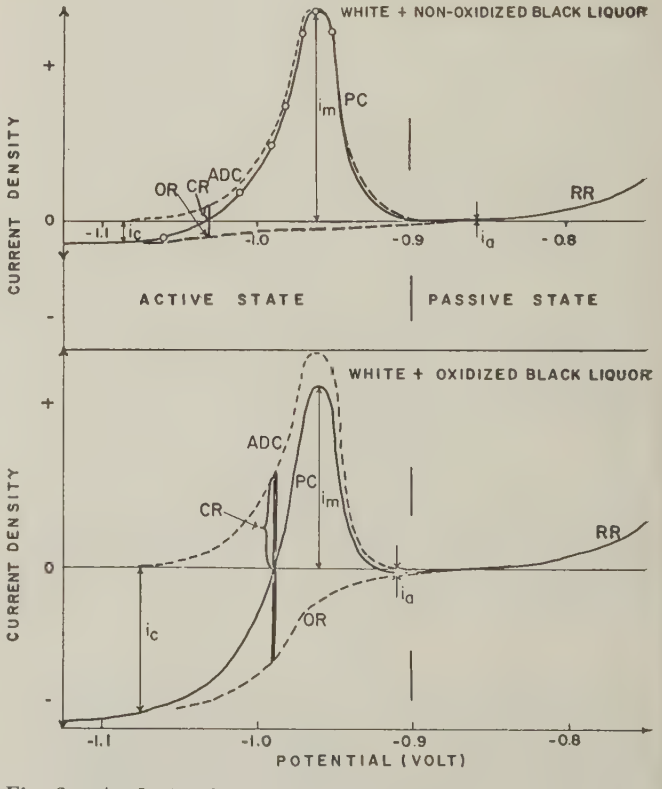

Fig. 3. Analysis of a schematic polarization curve of carbon steel in 60% white and 40% oxidized black liquor at 100°C.

two reactions are equal. However, the application of an external potential causes a change in the rate of both. In order to interpret the polarization curves obtained in studies of corrosion phenomena, it must be borne in mind that the current actually measured is the sum of the oppositely directed currents of the reaction. This may be illustrated from Fig. 2 which shows a typical polarization curve of carbon steel in a mixture of 60% white and 40% nonoxidized black liquor at about 100°C. Between −1.1 and −0.9 v. (relative to a saturated calomel cell) the polarization curve (PC) is composed of the anodic dissolution current (ADC) as a positive current and the current of the oxidizing reagents (the depolarization current (OR)) as a negative current. At −0.9 v. the anodic dissolution current, and thus the corrosion rate, reach zero, and the passive range begins. At less negative values the polarization curve is identical with the curve of the reducing reagents (RR).

In Fig. 3 analysis of another polarization curve is illustrated. This was obtained with a liquor mixture identical with that of Fig. 2, except that oxidized instead of nonoxidized black liquor was used as make-up. The change to oxidized black liquor causes a strong increase in the current of the oxidizing reagents (OR), which in turn shifts the polarization curve considerably to more negative values. Also, the minimum current in the passive range at about −0.9 v., which is slightly positive in Fig. 2, is shown to be slightly negative in Fig. 3. This difference is of importance with reference to the stability of the passive state. The passive state is stable where the polarization curve crosses the zero value of the current. In the mixture of white and oxidized black liquor the passive state is stable at −0.86 v. (Fig. 3) but it is unstable in the mixture of white and nonoxidized black

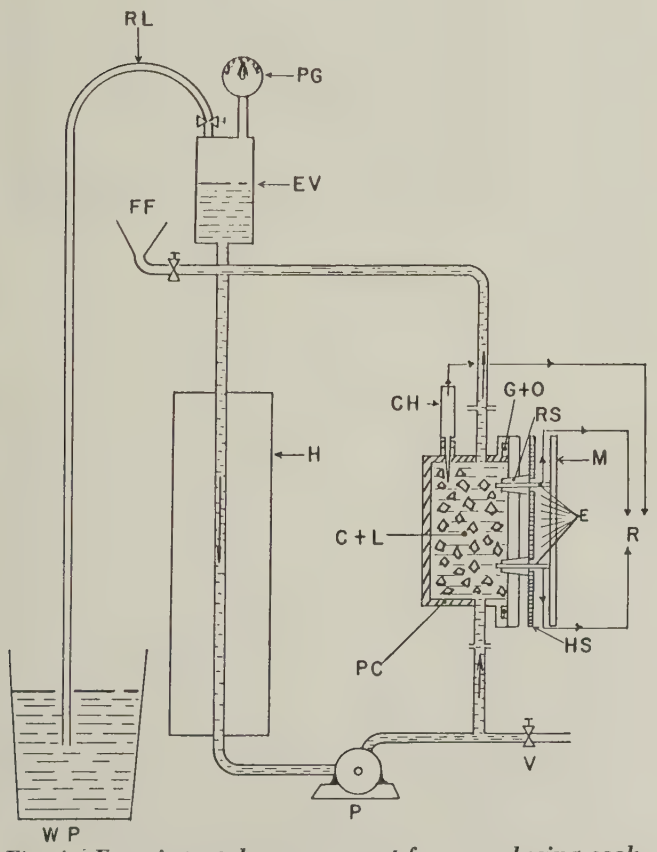

Fig. 4. Experimental arrangement for reproducing cooking conditions

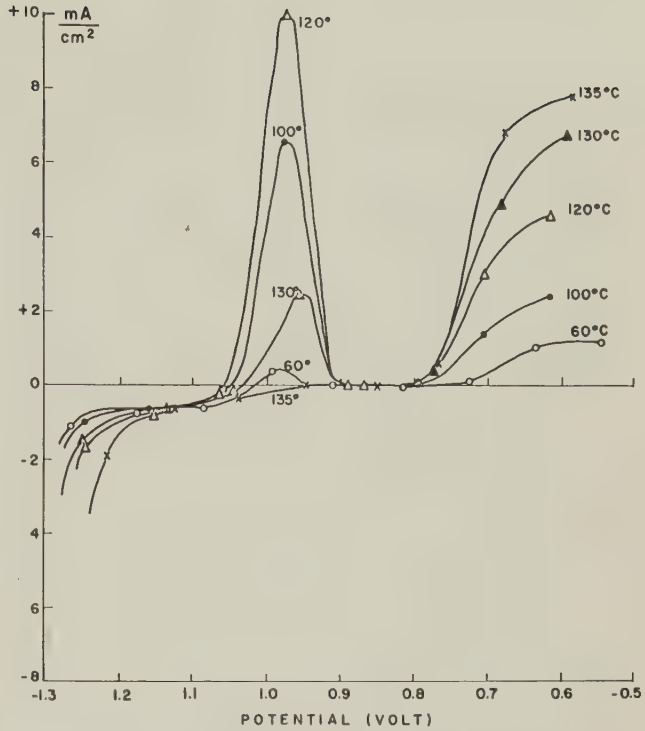

Fig. 5. Polarization curves measured during a laboratory cook in a mixture of 50% white with 50% nonoxidized black liquor from Marathon Corp.

liquor (Fig. 2). In the latter case, the current supplied to maintain passivity must be higher than the minimum current in the passive state; any area which does not receive the minimum current is reactivated.

This difference becomes important when anodic protection is considered. Not only is more current required with the nonoxidized black liquor mixture than in the mixture of oxidized black liquor, but also current must be applied continuously until the passive state is stabilized. In the mixture of oxidized black liquor too, the protecting current can be switched off after complete passivation is reached.

By way of comparison, it is also of interest to consider cathodic protection. In a mixture of oxidized black liquor with white liquor cathodic protection is established, i.e., the corrosion is zero (Fig. 3), when the potential of −1.1 v. is reached over the whole surface. This requires a considerable current which must be maintained continuously at the entire surface. Of course, in remote areas which receive a less-than-average current the corrosion would continue almost undiminished.

To obtain complete protection a current has to be supplied to all areas of the digester. This requires: (1) the current at the potential of −1.1 v. to maintain cathodic protection (Figs. 2 and 3), (2) the minimum current at the potential of −0.85 or −0.9 v. to maintain anodic protection. To passivate the digester a high initial current has to be applied for a short period to overcome the maximum current of the polarization curve. This high initial current is not required simultaneously over the whole digester because passivated areas need almost no current to maintain passivity and the digester can be kept in the passive state from the moment the liquor level reaches the electrode. Hence the actual current requirement is only a minor fraction of the maximum current.

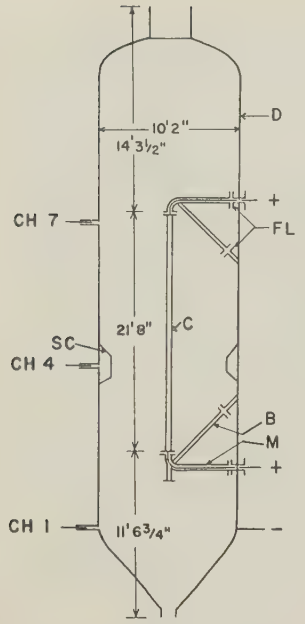

Fig. 6. Digester equipped with cathode and three calomel half-cells

It was found during the previous study (*6*) that when no current is applied the oxidized black liquor causes a rapid decline of the current maximum of the polarization curve and an early shift to the passive state. Cathodic protection can be expected to prevent this shift to the passive state and to keep the digester in the active state, thus prolonging the period of corrosion of areas insufficiently supplied with current. But anodic protection would cause an immediate shift of the potential to the passive range.

From Figs. 2 and 3 it may be concluded that the conditions for application of cathodic protection are improved by changing from a mixture of white and oxidized black liquor to a mixture of white and non-oxidized black liquor, and even more by changing to whole white liquor. Hence anodic and cathodic protection are complementary in the range of their applicability. Alterations in the conditions which improve the applicability of anodic protection render cathodic protection less effective and vice-versa.

Equipment Developed for the Application of Anodic Protection in Digesters

Recording Polarization Curves During Cooks. In the previous section the importance of polarization curves in applying anodic protection was discussed. These curves must be measured under rapidly changing conditions in a cook caused by the rapid drop in the sodium hydroxide concentration and the rapid rise in temperature. For this purpose an apparatus (Fig. 4) was developed which reproduces cooking conditions. The pressure chamber (PC) takes up the chips and partly the liquor (C + L). The nine carbon steel electrodes (E) are introduced into the chamber through rubber stoppers (RS). The heater (H) controls the temperature and the pump (P) maintains the circulation of the liquor.

During the experiments these nine steel electrodes are kept at equidistant potentials, with about 80 mv. potential difference between succeeding electrodes, by means of a series of resistors as described above. By recording the potential of one of them, and the total potential differences applied, it is possible to calculate all the other potentials. The current entering or leaving them is recorded on the same chart and the temperature as well. With these data polarization curves are constructed. The curves in Fig. 5 may be considered as a typical series of polarization curves. They were taken in a mixture of 50% white and 50% unoxidized black liquor during a laboratory cook at the Marathon Corp. of Canada Ltd. The negative current in the potential range from −1.2 to −1.05 v. is due to the reaction of oxidizing substances; the maxima of the current between −1.05 and −0.9 v. are due to corrosion, and the rapid increase between −0.8 and −0.7 v. is caused by reducing substances. It is of interest to note the maximum reached at 120°C. and the rapid decline commencing at 130°C. and higher when the current reaches zero and below. Under otherwise unchanged conditions, the rapid increase of the current maximum with temperature would continue; its decline is interpreted as an effect of the rapid decrease in alkalinity (more accurately), by the decrease of the concentration of unhydrolyzed sodium sulphite (*2*) and agrees with the shift of the potential to the passive range in the later phase of the cook. This shift even occurs without applying current as reported below. It is also interesting to note the rapid increase of the current in the range of −0.8 to −0.6 v. which is due to reducing agents. According to the principles outlined above it can be concluded from these results that a considerable current is initially required to overcome the current maximum and to reach passivation. However, later on the current can be reduced and finally switched off entirely.

The Cathode. The mill scale experiments described in the following were carried out at the Marathon mill of the Marathon Corp. of Canada Ltd., in digester 1. The cathode used for the experiments was developed by Corrosion Service Ltd. in Toronto.

The cathode, consisting of 2-in. steel pipe, was suspended in the axis of the digester (Fig. 6). Insulated flanges separated the cathode from the support assembly and the support assembly from the digester shell. Teflon was used for insulation.

The Calomel Reference Electrode. The continuous measurement of the potential difference between steel and liquor is necessary for the proper application of anodic protection. This potential difference indicates whether the steel surface has reached the passive state, where it is well protected against corrosion, or is still corroding more or less rapidly in the active state.

For this purpose a simplified, very reliable version of the Ingruber electrode (*4*) was developed, as will be reported later (*8*). It is a saturated calomel reference electrode with a closed stem. It can be used continuously for long periods without any attention, and it can be

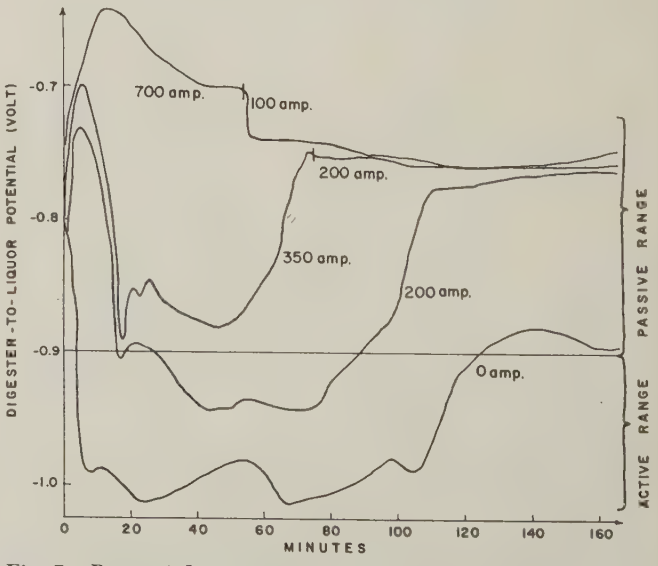

Fig. 7. Potential-time curves recorded by varying the current during indirectly steamed cooks

placed in any position required. Two electrodes of this type were used for 5 days continuously in digester 1, and were still accurate after this application. It is expected that continuous use for 2 to 3 months will be possible with the latest design. Thus this reference electrode should be well suited for continuous application. With anodic protection it will be used to ensure that passivation is maintained continuously throughout the cook.

In the digester experiments, potentials were recorded with electrodes placed at three spots where the current supply was potentially insufficient: (1) above the cone, (2) below the screen, (3) in the upper part of the digester.

Potential Time Curves Recorded During Anodic Protection

Earlier, as a result of laboratory experiments (*6*), it is suggested that oxidized black liquor should be used for make-up.

This is particularly important if the ratio black to white liquor is low, as it was during most of these experiments. But for reasons beyond the scope of this investigation oxidation of the black liquor used for making up the mixtures during the tests could not be carried out. Hence, *anodic protection had to be tested in a mixture of white and nonoxidized black liquor where the ratio of black to white liquor was low, i.e., under conditions which are least favorable.* The results prove that anodic protection is possible even under these extreme conditions. But it is expected, and confirmed by dependable data, that *more favorable conditions can be provided in any digester.* Hence, *the actual application will be carried out with a minor fraction of the current required in these first trials.*

To be a complete success, anodic protection has to keep the digester shell in the passive state right from the start, or at least that part of the shell reached by the liquor level must be passivated. The effect of insufficient current is seen from the potential-time curves (Figs. 7 and 8), which were taken at reference electrode 1 (Fig. 6) during indirect steamed cooks employing a mixture containing 43.1% nonoxidized black liquor, except for one curve measured at 700 amp. which was taken in 37.2% black liquor. Without applying anodic protection the steel is in the active state for 2 hr.; then the shift of the potential time curve indicates that the steel has become passive. During the application of 200 amp., the steel potential is less negative throughout the cook and the shift to the passive range occurs earlier. When 350 amp. is applied, the surroundings of the calomel electrode are in the passive state throughout the cook as the potential values show. However, the low minimum of the potential values makes it evident that some area, probably in the digester cone, was still in the active state and that 350 amp. was insufficient. It took 700 amp. for 55 min. to passivate the entire cone; then after 55 min. the current was reduced to 100 amp. without a reactivating effect. The passivation of the whole digester took 800 amp.

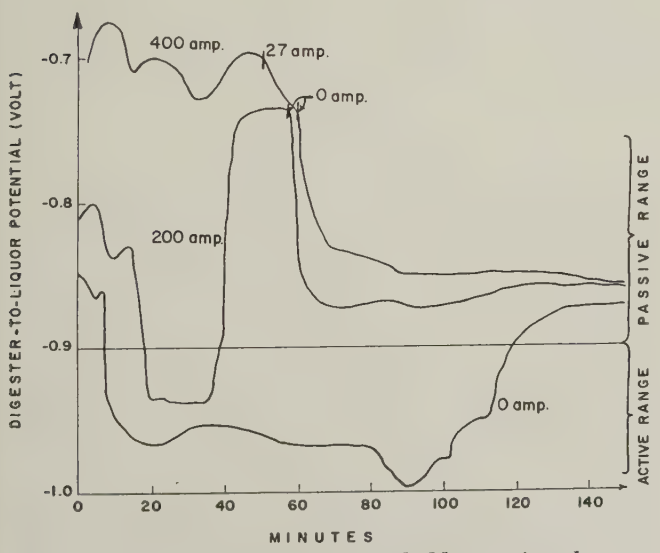

Fig. 8. Potential-time curves recorded by varying the current during directly steamed cooks

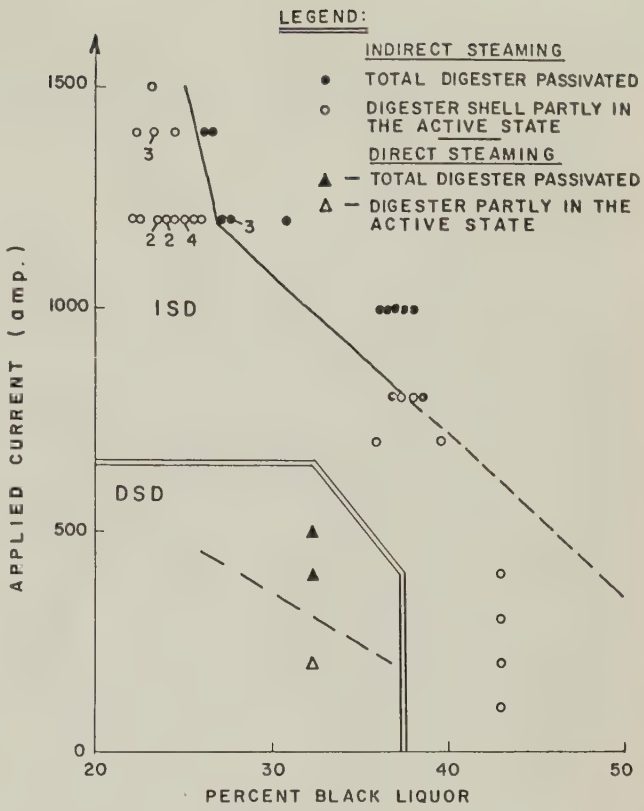

Fig. 9. Passivating effect of current as a function of liquor composition and steaming method

The effect of increasing current during directly steamed cooks in a mixture of 32% black liquor is shown in Fig. 8. Without applying anodic protection, the steel became passive after 2 hr. cooking time. When applying 200 amp. the duration of the active state was limited to 25 min. Four hundred amperes were sufficient to passivate the digester. When the protecting current was switched off after 60 min., the digester continued to stay passive. This fact indicates that the passive state was already stable.

As a result of previous work (*6*) it was thought that an increased ratio of black to white liquor decreases the quantity of current required for passivation. There was an unexpected chance to prove this statement, as the liquor composition changed considerably between carrying out the third and fourth group of experiments in the digester. Table I gives a survey of the liquor conditions and current requirements during the cooks. It is interesting to note the increase of the minimum current requirement from 800 to 1500 amp. when the liquor

Table I. Average Liquor Composition and Minimum Current Required During Mill Cooks

Dates	Number of experiments	Steaming	NaOH eFF., lb./cu. ft.	Liquor data: Volume, cu. ft. Black	White	Total	Black, %	Current required: For passiv., amp.	Duration, min.	Holding, amp.
April 23–24	5	Indirect	5.06	720	980	1700	42.4	...	..	...
June 19–23	12	Indirect	5.18	567	958	1525	37.2	800	50	150
June 24–26	10	Direct	5.27	443	931	1375	32.3	400	60	0
Sept. 4–8	28	Indirect	4.93	357	1071	1429	25.0	1500	60	250

composition shifted from 37.2 to 25.0%. A survey of the results of the mill tests is given in Fig. 9 where the current applied initially is plotted against the liquor composition. The filled in points on the figure indicate that passivation was attained at all three electrodes. As expected, the addition of black liquor decreases the quantity of current required for passivation very rapidly. Another result of basic importance is that the directly steamed digester (DSD) is passivated by about 40% of the current required for passivating the same digester during indirectly steamed cooks (IDS). It can be added that the quantity of current to be applied for anodic protection has to be chosen at least 50% higher than the limiting values in order to be sure of protection during the usual changes in liquor composition and cooking procedure.

DISCUSSION

The potential-time curves recorded during anodic protection are in excellent agreement with the predictions made previously (*6*). This confirms the soundness of the approach and the usefulness of the new methods of recording and interpreting polarization curves. It also shows that this study provides a reliable basis for making further predictions and generalizations. Summing up the results, it can be stated that the quantity of current required for passivation is strongly decreased by: (1) increasing the addition of black liquor, (2) changing from indirect to direct steaming, (3) replacing nonoxidized with oxidized black liquor, (4) decreasing the concentration of unhydrolyzed sodium sulphide, (5) increasing the degree of overscaling.

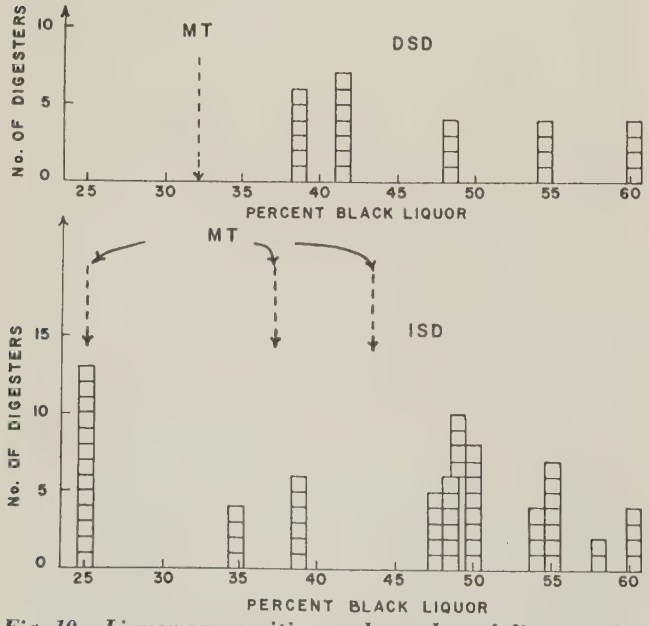

Fig. 10. Liquor composition and number of digesters installed in Canadian alkaline pulping mills

To compare the conditions experienced during these cooks with conditions in digesters at other mills, a survey of the number of digesters which were in operation in Canadian alkaline pulping mills in 1953, as a function of the ratio black to white liquor, it plotted in Fig. 10. In the directly steamed digesters (DSD) a mixture containing at least 38% black liquor is used; this compares very favorably with 32.2% during the mill test (MT). Even without oxidation of black liquor, the passivation of the directly steamed digesters should be possible by applying 500 amp. or less initially for 1 hr., and 50 amp. or no current at all for the remainder of the cook. Oxidation of the black liquor would reduce duration and quantity of the initial current and would render the holding current unnecessary.

Most of the indirectly steamed digesters were fed with at least 47% black liquor. However, three of the mills used less, one of them only 25%. Preoxidation of the black liquor would be advisable for the application of anodic protection in all three, but would be definitely required in the latter case. In the mills fed with at least 47% black liquor, oxidation would be advantageous, but not necessary. To passivate indirectly steamed digesters, a current of 500 amp. reduced after 1 hr. to 50 amp., is estimated to be sufficient if the black liquor is preoxidized in mixtures in which it makes up less than 50%. These conclusions are expected to be valid even though variation in the protection by liquor scale and the strength of white liquor may cause some deviation in the behavior.

These conclusions may only be valid when the liquors are mixed before feeding, in order to prevent local activation by whole white liquor. In the U.S.A. and abroad, liquor composition and cooking conditions are, no doubt, comparable to these Canadian conditions. Hence, anodic protection is expected to be applicable generally to stationary alkaline pulping digesters provided that the black liquor is oxidized when the black/white liquor ratio falls below a certain limit.

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Smoothness Measurements with Ink Films

A. T. LUEY

Experimental data are presented showing ink film requirements at various impressions to obtain complete ink coverage on boxboard. An empirical formula is derived for low ranges of impression relating ink film requirements to a constant (K_1) characteristic of the sample and to the amount of impression. At high ranges of impression the ink film requirements are equal to a second constant (K_2) characteristic of the sample. K_1 is the extrapolated value of smoothness at an impression of 0.001 in. and it was found to be related to the visual smoothness of the board as measured by the Scheid smoothness tester. It is concluded that the printing smoothness at low amounts of impression is a function of the free surface smoothness and the amount of impression applied.

In the printing of boxboard by the letter press method the pressman has two major operating variables that can be used to compensate for variations in smoothness. These are (1) the amount of impression, and (2) the ink film thickness.

This paper is a study of test results in which these two parameters are varied and of the development of a formula that will predict the printing smoothness characteristics of boxboard.

The term "impression" means the caliper of the board plus the packing papers in excess of the space between the plate and the bare impression cylinder. It is generally expressed in thousandths of an inch or "points." Thus, if the space between the top of the plate and the impression cylinder is 0.040 in. and the caliper of the board plus the packing papers is 0.047 in., then the impression would be 0.007 in. or 7 points. The terms "points of impression" and "impression" will be used throughout this paper.

TEST METHOD

Printing test procedures in which the impression and ink film thickness are varied have been described (*1*, *2*) and a description is given in Appendix I. In this series of experiments a step wedge printing plate was used.

TEST RESULTS

The results of a typical experiment are illustrated in Fig. 1. Each point in the graph illustrates the amount of impression required to obtain a complete coverage of ink on the sample at that particular ink film thickness. The curve is drawn to fit the lowest points which represent the minimum ink film thickness required at the given impression to obtain a complete coverage. The area below and to the left of the curve represents conditions of break-up or incomplete coverage of ink; that to the right and above the curve represents solid coverage.

Attempts to reduce the impression below 4 points were usually unsuccessful or unreliable. In this low range the ink film thickness required is usually excessive in relation to normal printing.

PRINTING SMOOTHNESS

It is theorized that the minimum ink film thickness required at a given impression is a measure of the smoothness of the board under these conditions. If the variations in the board's surface are greater in magnitude than the ink film thickness then we would expect break-up to occur. If these variations are less than the ink film thickness then the ink will contact the entire surface and the coverage will be complete. Exceptions to this may exist for special sheets with unusual wettability characteristics and may exist, as noted above, in the very low ranges of impression.

It is proposed that the term "printing smoothness" be adopted and to mean the minimum ink film thickness required to produce a complete ink coverage at a specified impression.

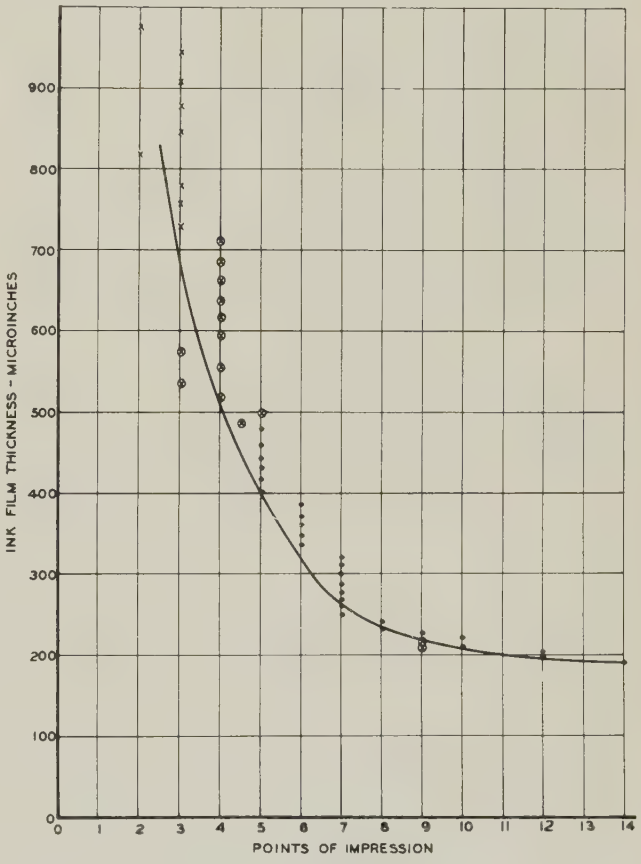

Fig. 1. Ink film thickness versus impression. Sample no. 1

Reference to Fig. 1 will show that the printing smoothness changes rapidly in the low ranges of impression. As the impression is increased the printing smoothness will approach a minimum value where

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further increases in impression have a negligible effect.

It is theorized that in the low ranges of impression, changes in smoothness are due to the reduction of the large irregularities in the sheet, such as wire and felt

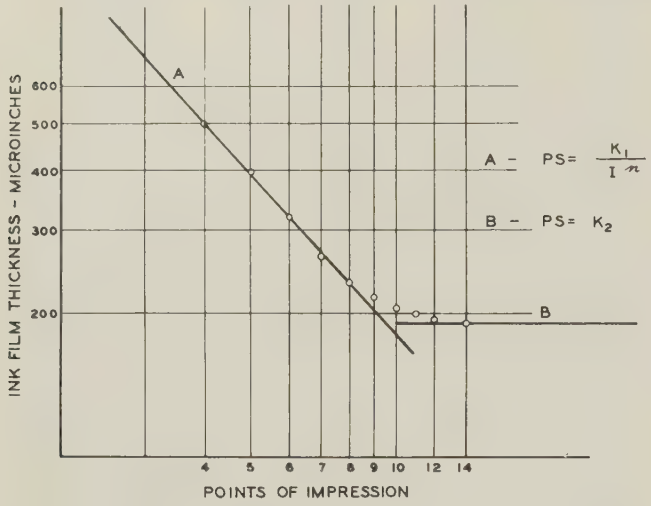

Fig. 2. Ink film thickness versus impression. Sample no. 1

marks. When these have been removed we have minute irregularities remaining such as intrafiber voids. At this point we are at the bottom of the curve and increased impression appears to have no effect on this type of roughness.

Based on this theory the paramount factor affecting printing smoothness in the low ranges of impression will be the large variations due to such items as felt and wire marks and the changes effected in them by compression. At the high range of impression the effect of the felt and wire marks will be eliminated, and at this point the printing smoothness is controlled by the minute irregularities such as the intrafiber voids.

MATHEMATICAL ANALYSIS

Figure 2 is a log-log plot of the curve in Fig. 1. The sloping line A represents the change in printing smoothness in the low impression range. The horizontal line

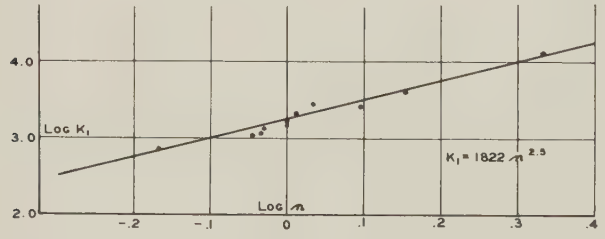

Fig. 3

B is the bottom of the curve in Fig. 1. The line A may be represented by the formula

$$PS = \frac{K_1}{I^n} \qquad (1)$$

where

PS = printing smoothness in microinches.
K_1 = constant.
I = points impression.
n = slope of line A.

The values of K_1 and n have been determined for a variety of boxboards (see Appendix I). They are shown in Table I.

At this point it became apparent that there was a relationship between K_1 and n. This has been plotted in Fig. 3. The formula relating K_1 and n was deter-

Table I

No.	*Grade of board*	*Caliper, in.*	*Weight, lb./M sq. ft.*	K_1	n
1	DWLM	0.035	142.0	2,000	1.06
2	WPCN	0.018	76.5	13,500	2.16
3	WPCN	0.026	107.5	4,100	1.42
4	WPCN	0.018	83.0	1,175	0.85
5	WPCN	0.018	74.5	1,100	0.80
6	WPCN	0.018	72.5	2,800	1.15
7	Clay coated news	0.018	77.5	1,500	1.00
8	Super WPCN	0.018	75.0	775	0.67
9	DWLM	0.018	84.0	2,100	1.02
10	WPCN	0.022	89.0	1,200	0.87
11	WPCKraft	0.022	87.5	1,700	1.00

mined by the theory of least mean squares and found to be:

$$K_1 = 1822n^{2.5} \qquad (2)$$

A statistical analysis of the data in relation to this equation shows that the correlation coefficient is 0.9921.

By substituting equation (2) in (1) we obtain:

$$PS = \frac{1822\ n^{2.5}}{I^n} \qquad (3)$$

It should be remembered that the above equation applies to the low ranges of impression only. In the high range of impression the printing smoothness will be equal to a constant that is affected by the minute irregularities. This can be expressed by the formula:

$$PS = K_2 \qquad (4)$$

In order to visualize the relative importance of the

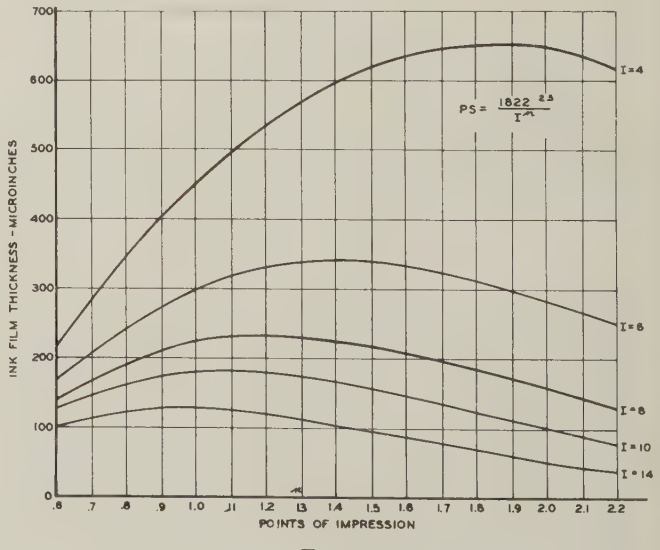

Fig. 4

various factors in equation (3), Fig. 4 has been drawn. This shows that the value of n is of major importance under conditions of light impression and becomes relatively unimportant at high impression. It illustrates

the importance of a *low* value of n, or a very high value in the range of light impressions.

Using equation (3) the values of printing smoothness have been determined at 6 points impression for the various values of n shown in Table I. These are compared to the values obtained experimentally in Table II.

Table II. Printing Smoothness—6 Points Impression

Sample no.	*Experimental data*	*From equation (3)*	*Difference*
1	305	313	11
2	270	260	10
3	345	343	1
4	253	268	11
5	265	249	16
6	355	329	25
7	250	304	54
8	230	202	28
9	330	308	22
10	250	271	21
11	280	304	24
		Av.	20

The correlation between the experimental and calculated values is graphically illustrated in Fig. 5. The correlation is 0.8134. It is interesting to note that sample no. 7, which is clay coated board, shows the largest difference. All other samples are white patent

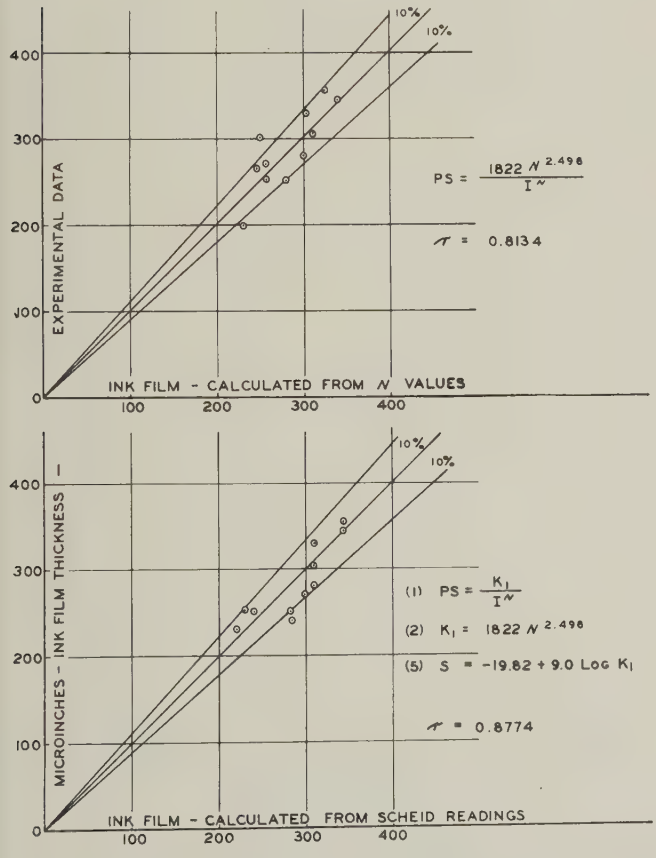
EXPERIMENTAL DATA
INK FILM - CALCULATED FROM N VALUES
10%
10%
PS = 1822 N 2.496 / I N
r = 0.8134
MICROINCHES - INK FILM THICKNESS
INK FILM - CALCULATED FROM SCHEID READINGS
(1) PS = K1 / I N
(2) K1 = 1822 N 2.496
(5) S = -19.82 + 9.0 Log K1
r = 0.8774

Fig. 5. Experimental versus calculated values of ink film

coated news with varying amounts of pigment filler in the top liner.

The average difference between the experimental and calculated values of printing smoothness is 20 millionths of an inch. The normal variation in the caliper of board is a possible explanation of this difference plus errors in experimental technique.

Thus it is concluded that equation (3) is a reasonably

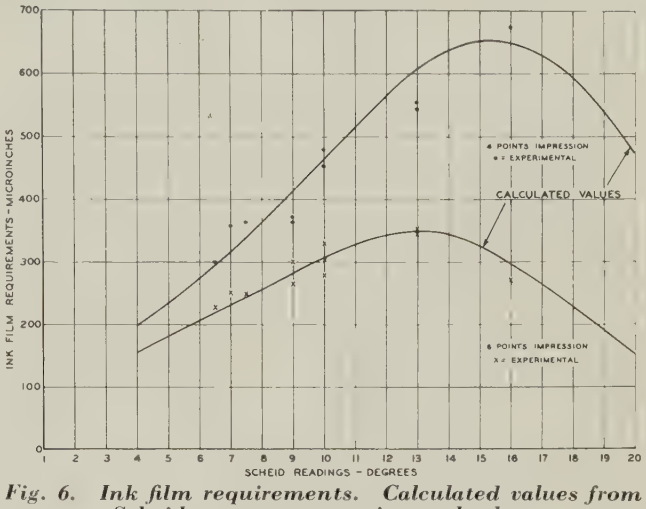

Fig. 6. Ink film requirements. Calculated values from Scheid test versus experimental values

good indication of the factors affecting printing smoothness in the low range of impression. It also should be noted that equation (3) could be rewritten so that the printing smoothness is expressed in terms of K_1 and

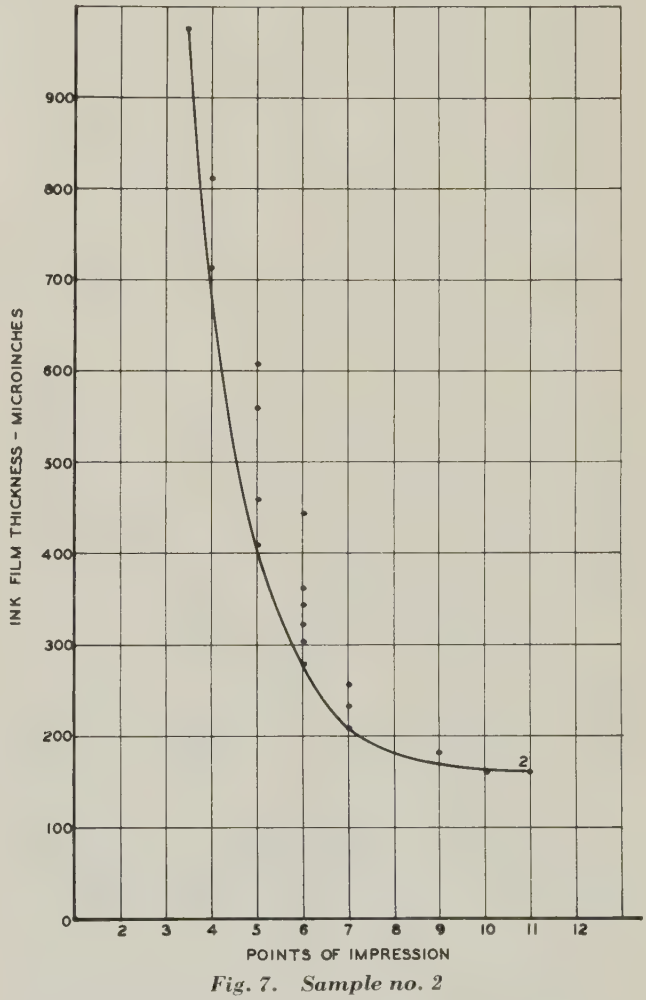

Fig. 7. Sample no. 2

impression. The value K_1 is the extrapolated value of printing smoothness at an impression of one point. Thus it appears that in the low ranges of impression

the printing smoothness is a function of initial surface roughness and impression.

It was noted that the samples having a high value of n or K_1 appeared rough, while those with low values appeared smooth. It is theorized that rough boards

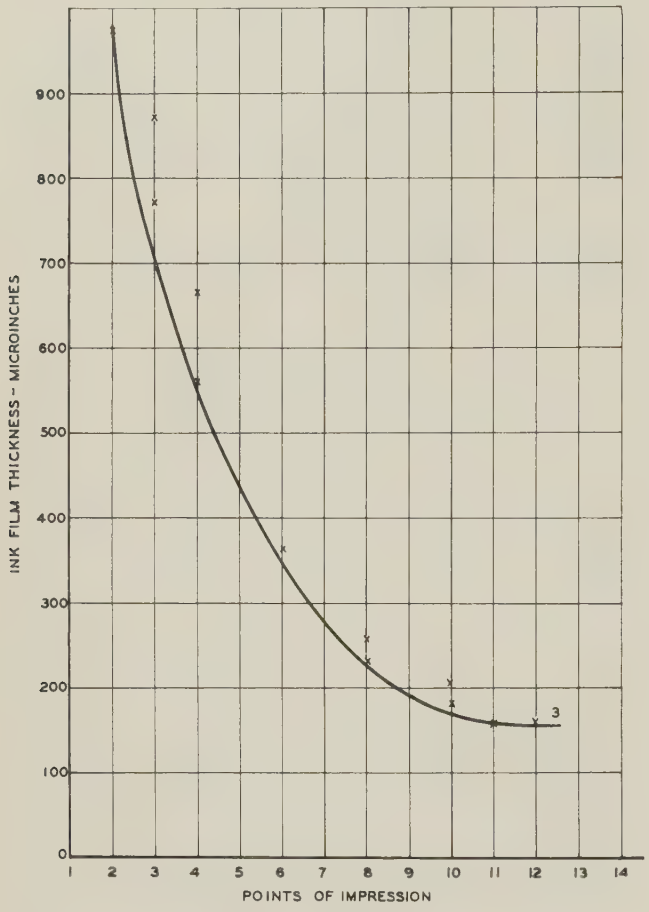

Fig. 8. Sample no. 3

have high values of change of printing smoothness (high values of n) because the compressive force is initially exerted on the high spots of the sheet and the force per unit area of contact is very high. Smoother sheets will contact a greater area of the sheet with the result that force per unit area of contact will be lower.

CORRELATION WITH SCHEID AND BEKK SMOOTHNESS TESTS

Because of the apparent correlation between visual roughness and high values of K_1 or n the samples were tested with a Scheid smoothness tester (*3*). In this test the sample is illuminated by a light source that can be rotated from 0 to 90°. Surface shadows will change with the angle of illumination. Some of the changes appear rather abrupt and thus provide a means of measuring the smoothness. The unit is used successfully for predicting the printing smoothness of coated paper, but no imformation is available concerning its use with boxboard.

The Scheid smoothness readings reported in Table III are the angles (from the horizontal) of illumination at which the first major change occurred in the shadow picture as the light was raised from the zero degree position.

The samples were also tested with the Bekk smoothness tester to see if there would be a correlation with K_2 which is a measure of residual roughness at high impression. The results are shown in Table III.

Table III

Sample no.	*Microinches* K_1	K_2	*Scheid, degrees*	*Bekk, sec.*
1	2,000	190	10	12
2	13,500	160	16	34
3	4,100	155	13	30
4	1,175	150	7	36
5	1,100	155	9	19
6	2,800	155	13	20
7	1,500	130	7.5	37
8	775	150	6.5	30
9	2,100	185	10	22
10	1,200	145	9	28
11	1,700	210	10	20

The values of K_1 were found to correlate with the Scheid readings according to the formula:

$$S = 19.82 + 9.0 \log K_1 \qquad (5)$$

The correlation coefficient was 0.7265.

The values of K_2 were found to correlate with the Bekk readings according to the formula:

$$\text{Log } B = 1.815 + 0.28 \log K_2 \qquad (6)$$

The correlation coefficient was 0.6831.

It was thought that perhaps this relation would be improved if the Bekk test were run at a higher pressure. Disproportionate changes in Bekk readings have been reported at higher pressures (*4*). Following this line

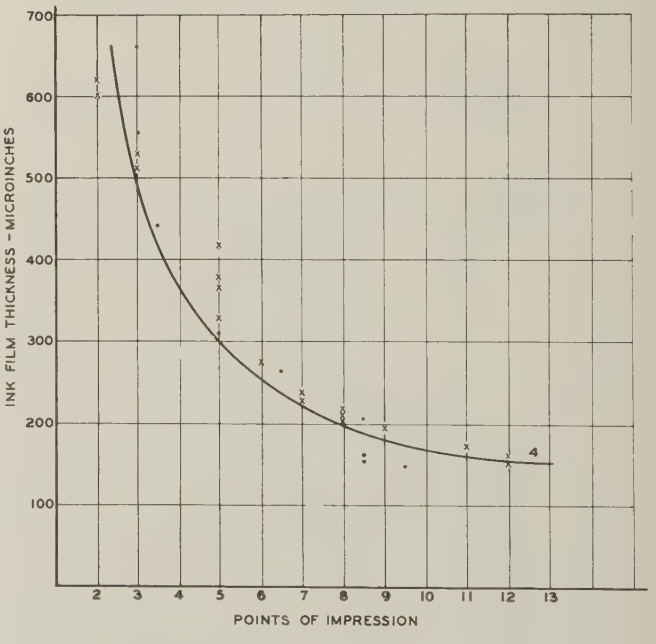

Fig. 9. Sample no. 4

of thought the samples were retested on the Bekk with a 50-lb. weight added to the lever arm. The results showed no correlation to either K_2 or K_1.

The relatively good relationship between Scheid smoothness and K_1 suggests that printing smoothness at low amounts of impression can be expressed in terms

of Scheid smoothness and impression. The formula expressing this relationship is cumbersome and it is easier to use the combined formulas:

$$PS = \frac{K_1}{I^n} \qquad (1)$$

$$K_1 = 1822\ N^{2.496} \qquad (2)$$

$$S = -19.82 + 9.0 \log K_1 \qquad (3)$$

Using these formulas calculations were made of ink film thickness requirements at 6 points impression. The results are compared to experimentally determined values in Table IV and Figs. 5 and 6.

Table IV

Sample no.	Ink film thickness—6 points impression: From Scheid readings	From experimental data	Difference
1	310	305	5
2	300	270	30
3	345	345	0
4	230	253	23
5	285	265	20
6	345	355	10
7	240	250	10
8	220	230	10
9	310	330	20
10	285	250	35
11	310	280	70
		Av. difference	21

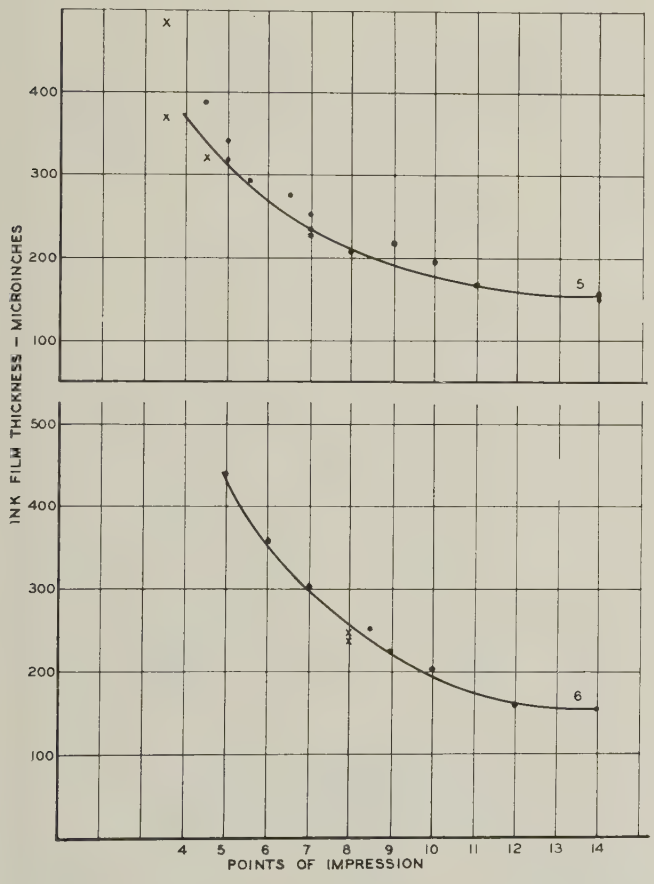

Fig. 10. Sample no. 5 (top) and sample no. 6 (bottom)

The data in Table IV are also plotted in Fig. 5. The correlation coefficient is 0.8774.

Since the ink film requirements or printing smoothness can be predicted from the visual roughness (Scheid readings) and the impression, it is evidence that the compressive characteristics of the board are not involved.

CONCLUSIONS AND COMMENTS

First, it should be emphasized that this work has been limited to a study of cylinder machine boxboard. The number of cases studied has been small, and as a consequence the formulas developed are offered as indications of trends or generalizations. A much larger group of samples would be required to develop empirical formula with relatively narrow confidence limits. In addition, other grades of printing material will undoubtedly have different sets of empirical formulas.

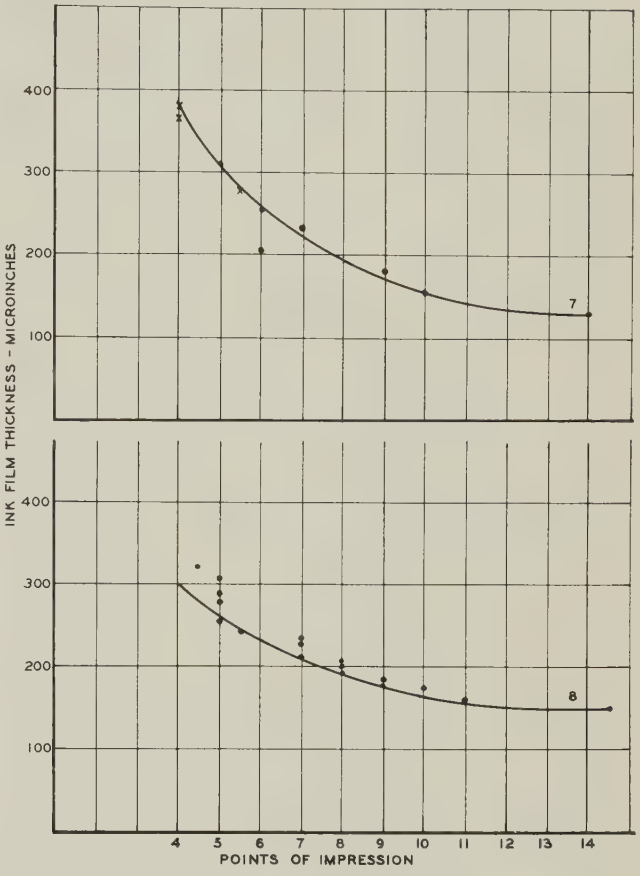

Fig. 11. Sample no. 7 (top) and sample no. 8 (bottom)

From the cases studied it appears that the printing smoothness should be studied under both conditions of relatively light and heavy impression. Under conditions of light impression the printing smoothness will be a function of the initial surface smoothness (K_1) and an inverse function of the impression. Under heavy impression the smoothness will be a function of the minute irregularities of the sheet such as the intrafiber voids (K_2).

The excellent relationship between K_1 and n (equation 2) appears to discount the possibility of a relationship between n (the rate of change in smoothness) and the compressibility characteristics of the board. This was a difficult conclusion to accept, as the author had long believed that the compressibility characteristics

of board were of substantial importance in affecting its printing smoothness.

The relationship between K_1 and the Scheid smoothness values and the relation between experimental and calculated values of ink film requirements using the Scheid readings are additional evidence that the compressibility characteristics of board are not involved in the low ranges of impression.

When we enter the high range of impression the ink film requirements become constant, so the compressive characteristics can be of no consequence here.

The relative importance of K_1 and K_2 will depend upon the type of printing to be done on the board. The author has seen examples of board with such a high

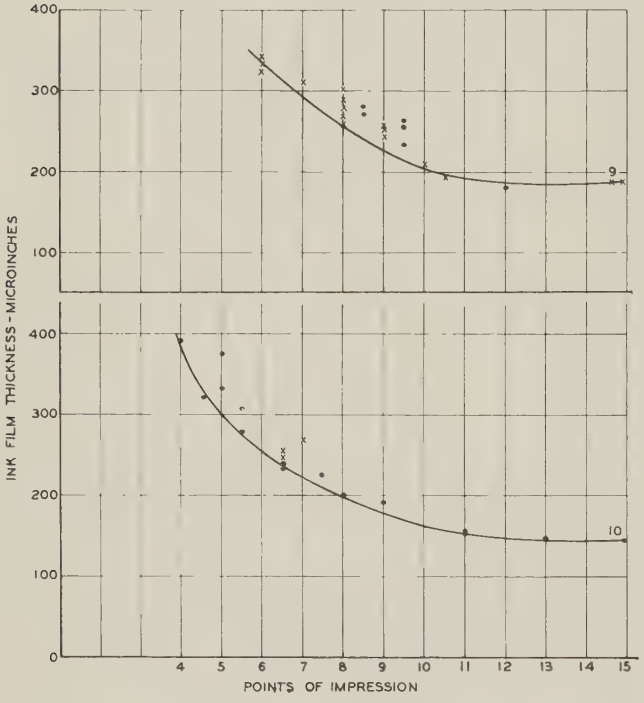

Fig. 12. Sample no. 9 (top) and sample no. 10 (bottom)

value of K_2 that ink consumption was 30% above normal in order to get complete coverage of solids at high impression. When this quantity of ink was carried on the press it resulted in the fill-up of half tones.

It is customary to print half tones with considerably less impression than solids, so in order to get a good definition of the fine screen work it is necessary to have a low value of K_1 and a normal or low value of K_2.

The advantages of smoothness testing by printing techniques are believed to be as follows:

1. The step wedge printing technique is a method in which the printing smoothness can be determined for both low and high impressions.

2. It is a direct method of measuring printing smoothness and does not depend upon the indirect correlation of some measurable board characteristic with printing results.

3. It permits the study of the two basic variables available to the pressman, ink film thickness, and impression.

4. The test does not give an integrated result. This is important, since a relatively minute percentage of the total test area can differentiate between satisfactory and unsatisfactory results.

5. The depth of the deepest depressions in the surface of the board can be measured in absolute units

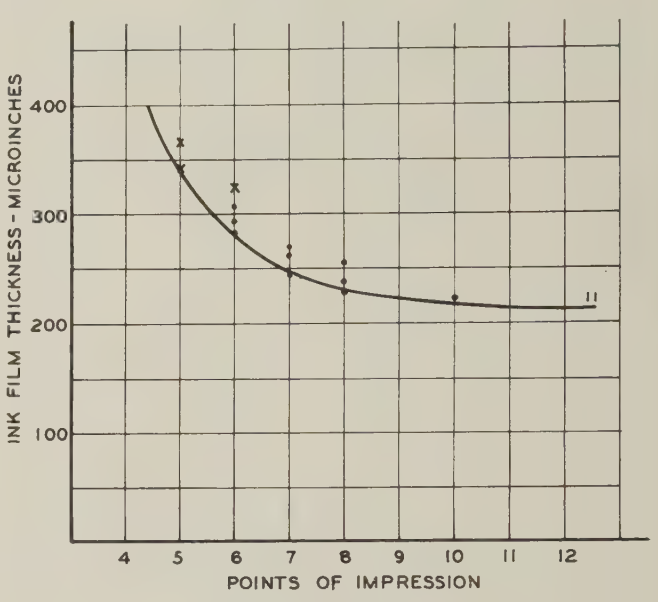

Fig. 13. Sample no. 11

under conditions of impression similar to those encountered in printing.

6. It will demonstrate the limiting conditions of ink film thickness and impression for satisfactory

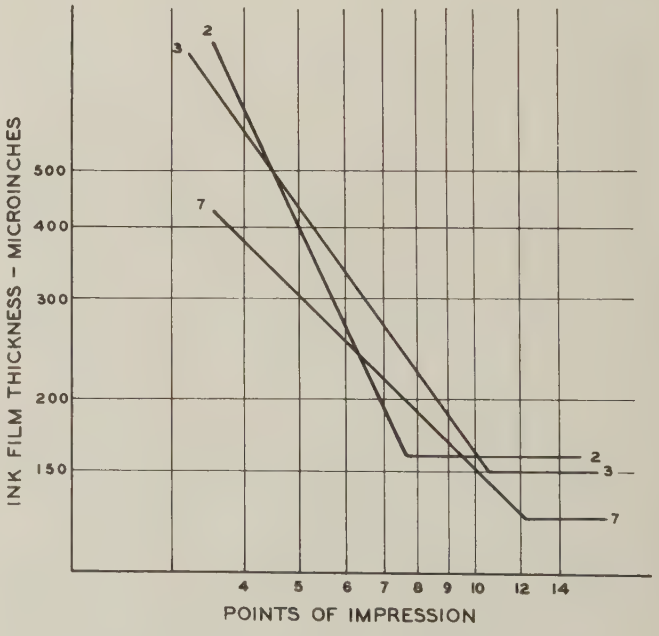

Fig. 14. Sample nos. 2, 3, and 7

printing which can be used in conjunction with carton plant make-ready.

7. Minor modifications of the test offer possibilities of studying other board variables such as pick and gloss ink characteristics.

APPENDIX I. PRINTING TEST PROCEDURE

Equipment:

1. Vandercook proof press model no. 4.
2. IPI track rated ink no. 1.
3. IPI ink volumeter.
4. Step wedge printing plate.

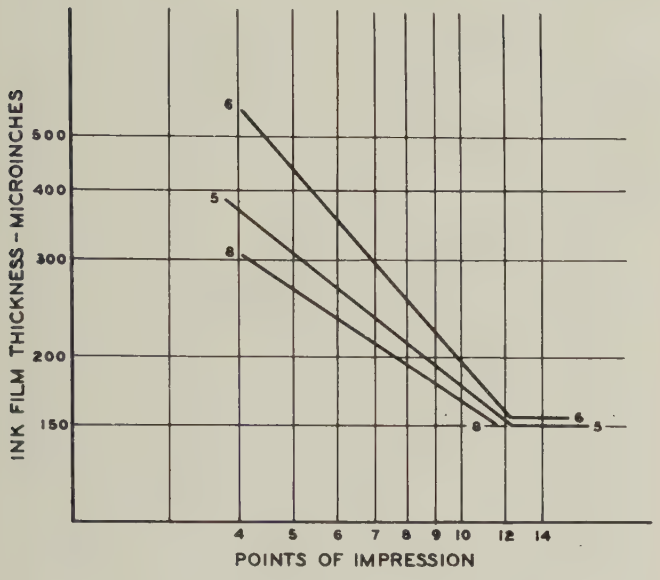

Fig. 15. Sample nos. 5, 6, and 8

The step wedge printing plate measures 2 by 6 in. Each step is 1 by 2 in. The plate is 0.9180 in. thick at the first step, 0.09190 in. at the second, etc., for six steps. Each step is machined to an accuracy of ±0.0001 in. The plate is placed in the bed of the press so that the shallow end is printed first.

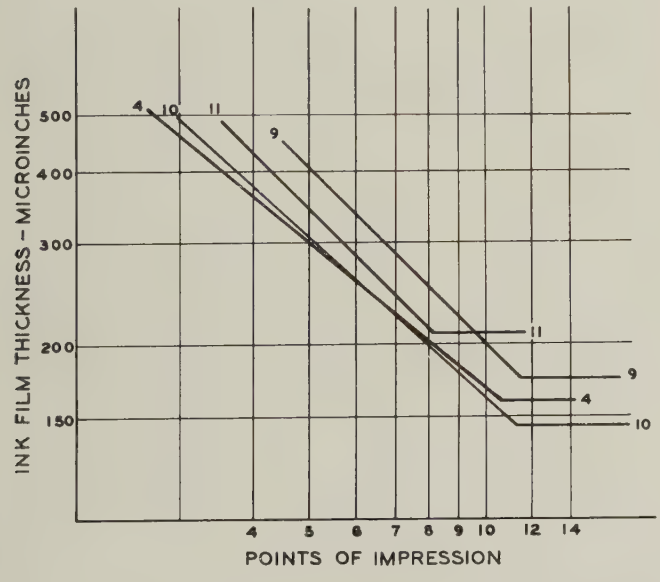

Fig. 16. Sample nos. 4, 9, 10, and 11

With the plate on the bed of the press, the bare impression cylinder is rolled into position over the shallow end of the plate (0.918 in.) and the clearance between the plate and impression cylinder measured. The value obtained (0.038 in.) was used to calculate total impression on the various steps of the plate.

In order to obtain an impression range of 5, 6, 7, 8 and 9 points the caliper of the board plus the packing would be 0.038 + 0.005 in. or 0.043 in. The caliper of the board plus the packing was measured prior to each proof. Board samples showing excessive caliper variation were discarded.

The distortion of the press was checked by measuring the displacement of the impression cylinder at various amounts of impression on a 3-in. wide plate. The displacement of the impression cylinder was zero at 0.020 in. impression and 0.002 in. at 0.032 in. impression. Thus it was concluded that this effect was of no consequence over the impression range used in the tests reported.

It should be noted that the points of impression apply to the combination of board and packing paper. Thus the actual impression or loss of caliper of the board is less than indicated.

A split distribution roll system was used on the press. The total area of the ink distribution system was measured, including the plate, and found to be 373 sq. in.

Each notch of the IPI Volumeter delivers 0.2 cc., which is equivalent to 32.7 microinches of ink film when spread over 373 sq. in.

It was assumed that on each proof 50% of the ink on the plate was transferred to the sample or 1.6% of the total ink in the system. After a series of proofs the press was cleaned, and re-inked to check results. This check procedure was followed on eight of the 11 samples tested.

Two inking procedures were followed. In the first a large quantity of ink was added and the film thickness gradually reduced by ink removal with successive proofs. This is time consuming and allows an accumulation of errors due to calculations of ink removal.

In the second method a relatively small quantity of ink was added, approximately sufficient to obtain a satisfactory print at very high impression. Proofs were pulled, reducing the ink film thickness until a change occurred in the impression requirements to produce 100% ink coverage on one of the steps, then a small quantity of ink (usually one notch on the Volumeter) was added and the cycle repeated.

After each addition of ink and after each proof it is necessary to let the ink distribution system run to reach equilibrium. In addition the inking rollers should be run across the plate several times.

The second technique will determine the printing smoothness at a variety of impressions with a minimum of proofs.

The results of tests are shown in Figs. 7 to 16 (sample no. 1 is shown in Fig. 1 and 2).

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Presented at the 43rd Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 17–20, 1958.

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Water Removal from Felts by Purging with Air Pressure

JEROME W. RIESE

The process of water removal from a papermaking felt by means of an air-pressure differential across the felt was investigated with a view to determining the important factors involved and the magnitude of the effect of each. The air-permeability of a felt is found to depend largely on the degree of saturation of the felt (in addition to the structural properties of the felt itself, which were not studied). The water removal process is found to occur in two phases, of which only the first, a "burst" of water particles, is of worth-while magnitude for papermaking application. This initial burst occurs at a constant time rate; the amount of water removed depends primarily on initial saturation and applied pressure.

THE felt on a paper machine must be continuously "washed and dried" to prevent an accumulation of small fibers from clogging its pores. Since the degree of felt saturation may have a considerable effect on sheet consistency, it is important to understand the processes which control felt saturation.

The washing, or addition of water to the felt, is accomplished by means of showers. The drying, or removal of water, may be done by mechanical pressure (wringer rolls), by air pressure (vacuum flatbox), by scraping, or by a combination of some of the foregoing (e.g., suction rolls). The present study is focused on the mechanism of water removal by air pressure, a process hereafter referred to as "purging."

It was initially believed that the purging process might be merely a particular case of two-phase (air and water) flow through a porous medium, for which the general theory had been worked out by previous writers, e.g., Muskat and Meres (*1*). Our problem would then have been merely to measure particular values for the theoretical flow constants. Preliminary data and observations, however, indicated that, while this theory could explain the flow of air through the felt, it was not the important factor in the removal of water. Since the felt was a rather thin porous medium, resulting in short travel paths, the viscous forces resisting water flow were very small compared to the surface tension or capillary type forces; it was these latter which ultimately decided whether or not the water would be "torn loose" from the felt.

With such fundamental uncertainty about the entire process of air purging, our present investigation was undertaken with the following objectives: (1) to discover the basic mechanism of water removal from a felt by air purging; (2) to learn which parameters are important in this process; (3) whenever possible, to measure these parameters and their effects, for the particular felts tested.

EXPERIMENTAL APPARATUS

Both of the experimental setups used in this investigation contained the following components: a compressed air source; a felt sample, containing a controlled initial amount of water, which was to be purged by the air source; and devices for measuring the pressure drop across the felt, the volume rate of air flow through the felt, and the amount of water remaining in the felt.

Figure 1 illustrates the operation of our "felt-tester no. 1." The air source, a water-sealed Nash pump driven by an electric motor, provided steady pressures in the range 3 to 10 in. Hg across the felt while delivering air volumes up to 20 cu. ft. per min. Moisture due to the water seal was removed from the air by a separator. The air flow rate was measured by either of the two orifice plates shown at the top center of the figure: a $^3/_8$-in. orifice in a $1^1/_2$-in. pipe and a $1^1/_2$-in. orifice in a 3-in. pipe. These were installed as per standard practice (*2*), including proper lengths of straight pipe before and after the orifices. Mercury manometers measured the pressure drop across the orifices, as well as across the felt itself.

The felt samples used were cut from an old used, but not worn away, pick-up topfelt (14% synthetic) weighing 0.671 g. per sq. in. air-dry. They were mounted on Lucite rings of $4^1/_2$ in. outer diam. and 3 in. inner diam.; for testing, each ring was bolted tightly to the end of the "felt-tester," as shown in Fig. 1. Five different samples were used in early experiments; since all five yielded almost identical data, subsequent tests were limited to a single sample. Felt weights (and hence the degree of saturation) after purging were measured by transporting the mounted sample to the weighing room in tightly shut cans to prevent accidental water loss.

"Felt-tester no. 2," shown in Fig. 2, resembled no. 1 except that a compressed air source replaced the air pump; this allowed the pressure range to be extended below 3 in. Hg. All dimensions were correspondingly smaller, including a $^3/_{16}$-in. orifice in a 1-in. pipe. Several circular screens were spaced along the upstream end of the Lucite outlet tube to diffuse the air before it reached the felt. The same felt samples were used as for no. 1.

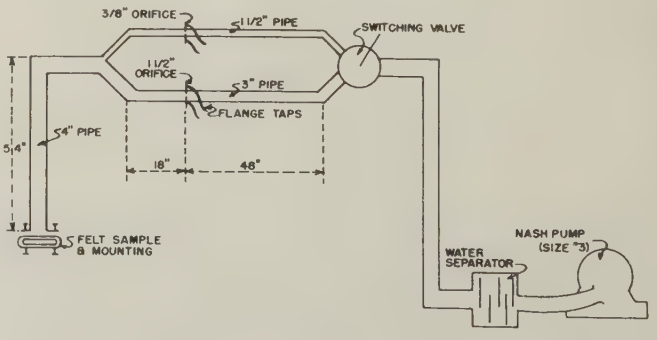

Fig. 1. Functional sketch of felt-tester no. 1

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DISCUSSION OF RESULTS

Our first experiments aimed at finding the amount of water remaining in an initially "saturated" felt after purging at various air pressures. A lack of consistency in the resultant data revealed, upon investigation, that two important variables (in addition to purging pressure) had to be controlled: the initial amount of water in the "saturated" felt (hereafter denoted as W_0), and the length of time that the felt was purged.

The latter quantity, purging time, has the effect shown in Fig. 3. For each data point, the felt was resaturated to the constant initial value $W_0 = 0.97$ g. per sq. in., and purged for a new length of time; the purging pressure across the felt in each case was maintained at $\Delta P = 5.0$ in. Hg. It is seen that the felt saturation drops almost instantaneously to a value $W_1 = 0.45$ g. per sq. in. (our measuring apparatus requires 5 to 10 sec. to reach equilibrium, consequently times shorter than this cannot be measured); thereafter, water is lost much more slowly by the felt.

Similar results, at other pressures and initial saturations, led to one of the most important conclusions of this report, viz., that felt purging by air pressure takes place in two steps. There is an initial burst as the larger pores are cleared of water, allowing air to flow through; further water is eroded and/or evaporated by the flow of air, a much slower process which eventually tapers off as the felt becomes dryer. This conclusion is supported by visual observation—the initial burst can be seen as a fine spray of particles ejected by the felt; thereafter, the moisture can be felt in the transmitted air, but few particles seen. One would expect the initial burst to depend largely on capillary-type forces, such that the smaller the pores, the larger is the air pressure needed to clear them; while the second step, in which air is continuously flowing through, would probably resemble the two-phase flow described by previous writers (*1*). Therefore, from this point on, our work attempted to characterize independently the two distinct steps in felt purging.

It is easily seen that step no. 1 is the more important for papermaking applications. Since vacuum box slots

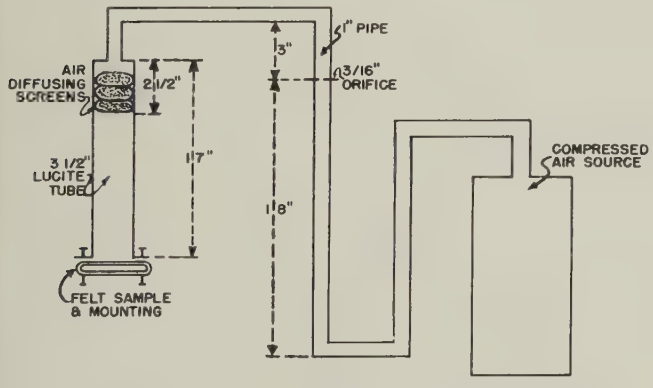

Fig. 2. Functional sketch of felt-tester no. 2

are usually ≤ 4 in. in width, and machine speeds ≥ 50 f.p.m., the felt on a machine is exposed to a pressure differential for less than half a second; while step no. 2 requires several minutes to produce significant water removal. For this reason, our investigation of the two-step purging process concentrated first on step no. 1. Figure 4 shows the effect of initial saturation W_0, and purging pressure ΔP, on the amount of water ΔW removed from the felt by the initial burst. Here, W_1 is the saturation remaining at the end of step no. 1, so that $\Delta W \equiv W_0 - W_1$.

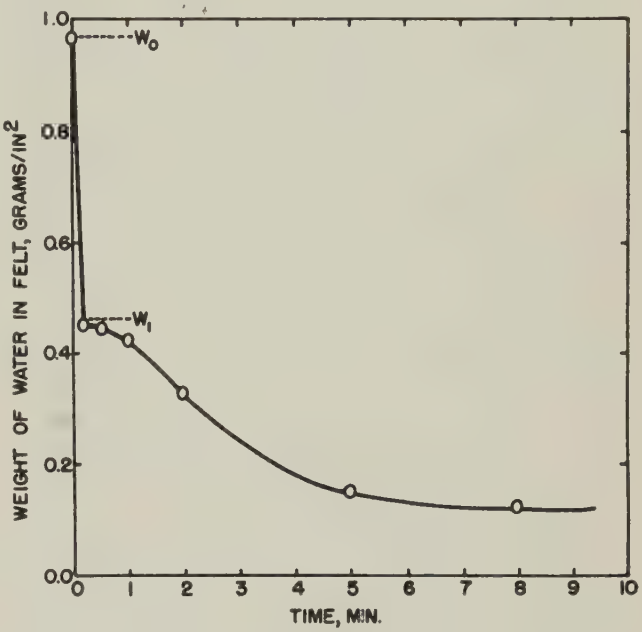

Fig. 3. Felt saturation versus purging time (purging pressure $\Delta P = 5.0$ in. Hg)

It is seen that, for any given purging pressure ΔP, the amount of water removed from the felt is a linear function of the initial degree of saturation; i.e.,

$$\Delta W = a(W_0 - b)$$

Furthermore, the slope of each of these lines is the same regardless of purging pressure; i.e., a is constant independent of pressure in the above equation, which may therefore be rewritten

$$\Delta W \equiv W_0 - W_1 = a[W_0 - b(\Delta P)] \qquad (1)$$

For the particular felt tested, the constant slope, a, in equation (1) has the value

$$a = 0.91 \qquad (1')$$

The pressure-dependent parameter $b(\Delta P)$, obtained from Fig. 4 and from additional data at intermediate pressures, is plotted in Fig. 5; its relation to the usual capillary pressure curve, as given by Scheidegger (*3*), may be easily seen by solving equation (1) for W_1. It is expected that a simple relation such as equation (1) might hold for felts other than the one tested in this experiment, although the parameters a and b would almost certainly be different.

Equations (1) and (1′) imply that, of all the water $W_0 - b(\Delta P)$ available for purging at a given pressure ΔP, 91% is removed by the initial burst (step no. 1). We have already seen from Fig. 3 that step no. 2 is very inefficient in removing the remaining 9%. The question naturally arises: could the pressure be turned off, and then on again, to take repeated advantage of step no. 1? (Practically, this would be equivalent to using two successive vacuum boxes on a machine.) This would certainly be true if the time between pres-

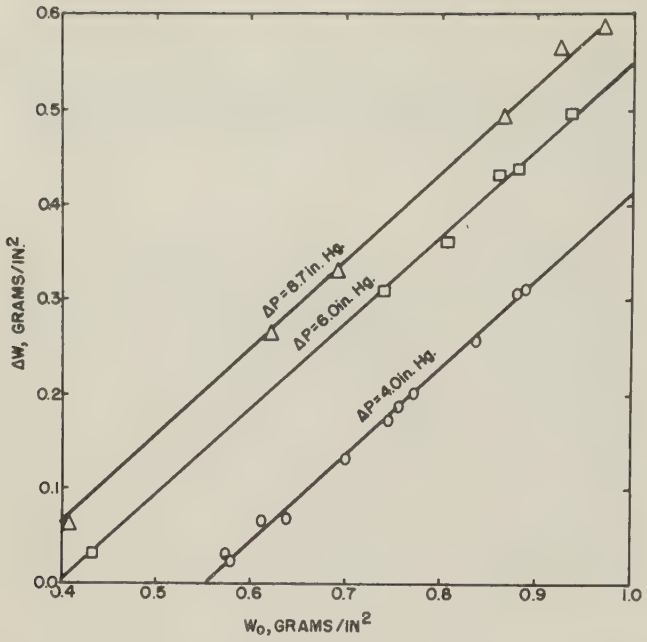

Fig. 4. Loss in water, ΔW, versus initial amount of water present in felt, W_0

sure applications were infinite, so that the water in the felt could be redistributed after the first purging, and "ready" for the second; repeated use of equations (1) and (1′) then yields:

$$\begin{aligned} W_1 &= 0.09[W_0 - b] + b \\ W_2 &= 0.09[W_1 - b] + b \\ &= (0.09)^2[W_0 - b] + b \text{ etc.} \\ W_n &= (0.09)^n[W_0 - b] + b \end{aligned} \qquad (2)$$

where W_n is the amount of water remaining in the felt after n pressure applications, with a very long time between successive applications. On the other hand, it would not hold for zero time between applications, in which case the very slow step no. 2 (Fig. 3) would hold for all pressure applications save the first. The experimental question is: At finite intervals (sufficiently short for use on a paper machine), would several successive pressure applications efficiently purge more water from the felt?

To answer this question, repeated purgings were run at 20-sec. intervals and at 60-sec. intervals. The results are shown in Fig. 6, together with the curve for zero-time-interval (step no. 2 of Fig. 3). Also shown is the theoretical curve for 15 sec. applications, with infinite time between applications; since the number of applications equals the total time of applications divided by the time per application, this is obtained by replacing equation (2) by

$$W(t) = (0.09)^{t/15 \text{ sec.}} \quad [W_0 - b] + b \qquad (2')$$

Equation (2′) yields a straight line on semilog paper. Although the finite-interval curves do indeed approach this straight line as the time interval increases, Fig. 6 shows that intervals of a minute or more are necessary if the second and subsequent purgings are to be of worthwhile magnitude. On this basis, we might suppose that more than one vacuum box on a paper machine, for the same purging operation, would be useless.

It is possible, however, that mechanical pressures (rubbing or squeezing) might assist the water to rearrange itself within the felt in a much shorter time. Initial qualitative trials, in which the felt samples are massaged between purgings, seem to bear out this hypothesis. Therefore two vacuum boxes, with a roller or scraper between them, might be of use, if one is interested in removing the final 9% of available water from the felt.

Step no. 1 in the process of felt purging had now been completely characterized, except to determine its duration of, and variation with, time. This determination could not be done with the apparatus described herein, which requires several seconds to reach equilibrium after the pressure is turned on. The obvious solution would be an apparatus with the pressure maintained constant, but the felt exposed to this pressure for only a fraction of a second—this is just the situation which exists on an actual machine. With this idea, preliminary tests were conducted with a setup (not described in this paper) on the experimental paper machine. The results, though not conclusive, indicate that step no. 1 occurs approximately linearly with time, over an interval of the order of 0.05 sec.

Attention was now focused on step no. 2, the air flow-water erosion phase of felt purging. Although this seemed to have no immediate application to papermaking, the availability of an experimental arrangement to measure air flow rates, as well as a general interest in the properties of textile filter media (see Cunningham, *et al. 4*), suggested such investigation. The quantity we attempted to measure here was the air permeability, defined by

$$K = \frac{dQ}{dt} \div \left[A \frac{\Delta P}{\Delta x} \right] \qquad (3)$$

where dQ/dt is the macroscopic volume rate of air flow, A the felt area, ΔP the pressure drop across the felt, and Δx the felt thickness. On the basis of a simple

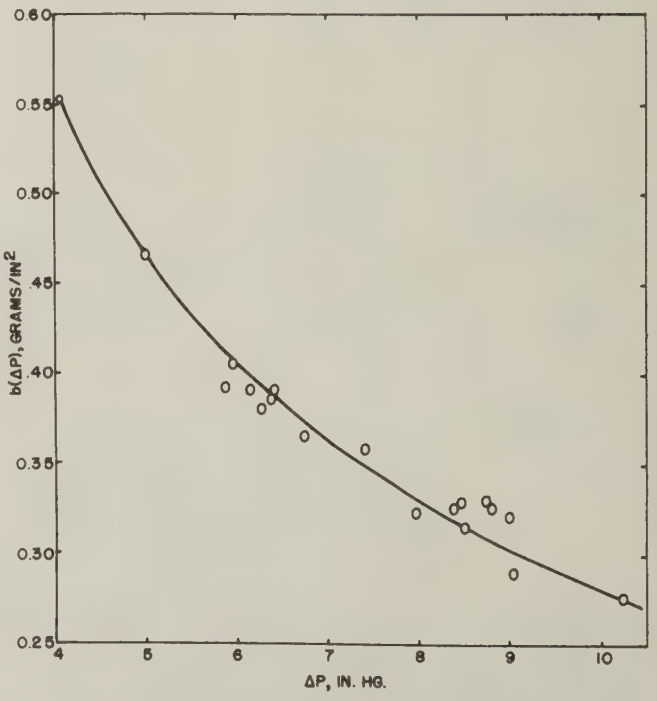

Fig. 5. Purging parameter $b(\Delta P)$ versus pressure drop ΔP across the felt. (See equation (1) of text for definition of b)

micrometer measurement, the felt thickness was taken to be

$$\Delta x \approx 0.1 \text{ in.} \qquad (3')$$

We then measured the air permeability K of equation (3) as a function of pressure drop Δx and degree of saturation W.

Results were as shown in Fig. 7. The air permeability was found to be essentially independent of flow rate or pressure drop, as demonstrated by the fact that all points fall quite close to a single saturation-dependent curve, despite the fact that these points were measured for a range of air pressures (0 to 10 in. Hg). Thus the pressure-dependence claimed by some previous references (see Scheidegger, *3*) was not found here. On the other hand, the dependence of air permeability on the degree of water saturation gives a curve very similar to that found by Wyckoff and Botset (*5*) for flow of carbon dioxide through sand partially saturated with water. The air permeability increases with decreasing water saturation. For a perfectly dry felt, the extrapolated value of K is between 4 and 5 in.^{4} per lb.-sec. For a woven wool felt weighting 14 oz. per sq. yd., Cunningham's measurements (*4*) yield a value for the air permeability (assuming 0.1 in. thickness, for the sake of comparison) of about 28 in.^{4} per lb-sec. One would expect this much larger value because: (1) his felt weight of 14 oz. per sq. yd. = 0.306 g. per sq. in. is less than half of ours; and (2) the very close weave of papermaking felts makes them much less permeable than an ordinary fabric of even the same weight. Therefore, our results are compatible with previous published data.

CONCLUSIONS

The purging of water from a papermaking felt takes place in two steps. Step no. 1, lasting less than 1 sec., consists of a burst of water particles from the felt as the larger pores are cleared to allow air to pass through. In step no. 2, the air flows through at a fairly constant rate, and the remaining water is slowly removed by erosion and/or evaporation.

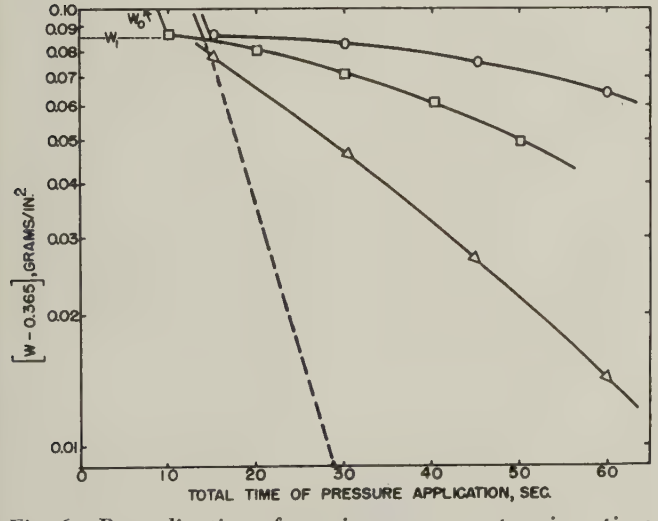

Fig. 6. Reapplication of purging pressure at various time intervals

Pressure $\Delta P = 6.3$ in. Hg.; $b(\Delta P) = 0.365$ g./sq. in. Key: ○—continuous pressure application. □—Discrete applications of 10 sec. each, 20 sec. between each. △—Discrete applications of 15 sec. each, 60 sec., between each. – – – – theoretical curve for 15-sec. applications infinite time between each.

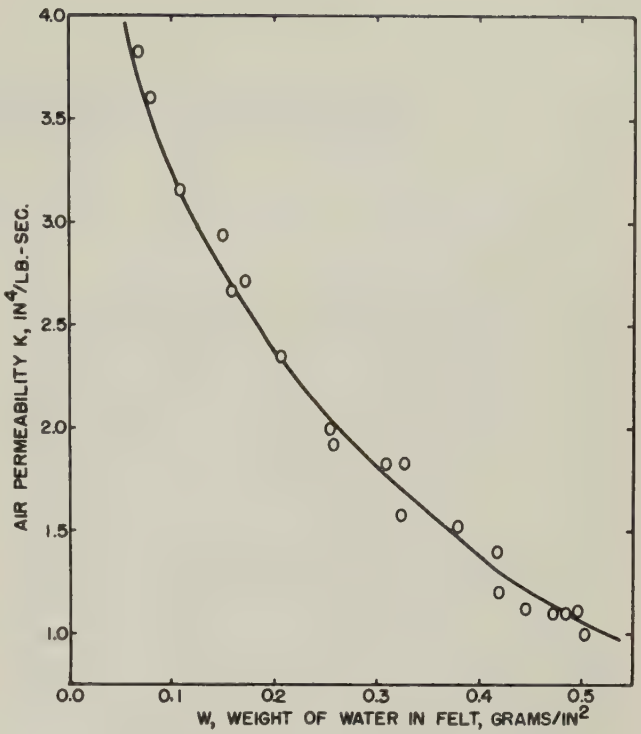

Fig. 7. Air permeability, K, of partially saturated felt versus degree of saturation. (Felt thickness = 0.1 in.)

Only step no. 1 gives sufficiently fast drainage to be of interest in present papermaking applications. The amount of water removed depends on the initial degree of saturation, and increases with purging pressure, as shown in Figs. 4 and 5. Repeated use of this initial burst is possible only if one waits a long time between pressure applications (see Fig. 6), or possibly if the felt is subjected to mechanical pressures between purgings.

In step no. 2, the rate of air flow through the felt is directly proportional to the pressure drop across the felt. The constant of proportionality, which is known as permeability, depends on the degree of felt saturation as shown in Fig. 7.

A more quantitative measurement of the small time interval required to complete step no. 1 would be useful as a criterion for vacuum box slit widths. Further experiments should also be done on the effect of mechanical pressures between purgings. Finally, tests similar to those reported here could be performed on different types of felts for comparison of their "purging parameters."

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Bacterial Deterioration of Woolen Felts

JOHN A. CARLSON and J. H. CONKEY

A factorial experiment involving the factors of pH, temperature, and cleaning has been completed for the purposes of determining the effects of these factors on the rate of bacterial deterioration of papermakers' woolen felt. These studies were conducted on an experimental felt machine. The following conclusions are made on the basis of statistical analyses of the data: (1) The degree of deterioration due to bacteria was dependent on the level of pH. The presence of bacteria at a pH of about 8.0 produced considerable damage to the felts in this experiment. No appreciable deterioration was observed at pH 5. This result was shown by losses in tensile strength and a microscopical examination of wool fibers. (2) Temperature did not significantly affect the rate of bacterial damage; however, the data indicates that temperature is more important than the statistical analyses show. (3) Highly significant losses in water drainage rates were noted as due to the presence of bacteria. This was true at both levels of pH and both levels of temperature. (4) The cleaning procedure used in this experiment did not significantly influence any of the measurements made to evaluate felt changes. (5) Felt thickness data showed the greatest degree of compaction for felts which exhibited considerable bacterial damage. Decreased drainage rates were not correlated with decreased felt thickness.

Felt deterioration due to microorganisms is of concern to the paper manufacturer within the general area of microorganism control. Woolen felts are subject to microbial degradation primarily because wool, being proteinaceous, is susceptible to proteolytic enzymes produced by certain species of bacteria and fungi, and conditions are often favorable for microbial activity within the paper machine system. Race (*1*) and Shema (*2*) have discussed this type of felt deterioration while Appling, Smith, and Fronmuller (*3*) and Binns (*4*) have demonstrated bacterial attack of woolen felts due to enzymolysis in the laboratory. Microorganisms, however, probably contribute more to woolen felt degradation than is presently known or realized. It has been demonstrated, for example, by Buckman (*5*), French (*6*), Drescher and Christensen (*7*), and Drescher (*8*) that bacterial cells apparently can be important in the plugging of felts. This would seem to be significant since not all microorganisms within a paper machine system are proteolytic and capable of attacking wool protein; however, presumably all microbial cells present could contribute to plugging.

Many factors may be important in the microbial degradation of felts in commercial paper machine use. Certainly, conditions of pH, temperature, available nutrients, etc., can influence the rate and degree of microbial action on the wool fibers. In addition, various other environmental conditions such as mechanical stresses (machine speed, felt tension, nip pressure) and the various components of a papermaking furnish may have their effects on the extent to which microorganisms cause felt damage.

This paper presents an investigation of the effects of three factors (pH, temperature, and felt cleaning) on the bacterial deterioration of woolen felts using an experimental "felt machine." The "felt machine" did not duplicate the conditions to which felts are subjected in commercial usage, especially the mechanical stresses. It did, however, approximate such conditions and it is believed the results of the study are realistic in terms of mill felt usage. The limitations of the apparatus were such that only a few of the factors of interest to this study could be included as variables. It would be necessary to design and construct a new and more efficient apparatus in order to perform experiments designed to study the effects of all the many factors which may contribute to the rate and degree of microbial felt deterioration.

This investigation was carried out at The Institute of Paper Chemistry under a general program of microbiological research sponsored by the Biological Control Committee of the American Paper and Pulp Association.

EXPERIMENTAL PROCEDURE

Felt Machine Operation

Figure 1 is a photograph of the experimental machine. It was a coating machine which had been revised and rebuilt for the purpose of these deterioration studies, and consisted of a series of seven rolls over which ran a felt approximately 26 ft. in length and 12 in. wide. One large rubber-covered roll served as the drive roll. The felt passed through press rolls at two points and over two rolls which were partially immersed in water contained in separate tanks (total water capacity about 50 gal.). Another chromium roll applied tension to the running felt by means of a lever mechanism with weights. A Nash felt guide was mounted on top of the machine to keep the felt in alignment. The maximum speed of the machine was approximately 400 f.p.m. A speed of 300 f.p.m. was chosen to be used throughout these studies. The nip pressures at the two press rolls were in the range of 5 to 7 lb. per in. of nip and the tension applied to the felt was approximately 10 lb. per in. of felt width.

Experiment Design

Since the purpose of this investigation involved a determination of the effects of various factors with regard to bacterial degradation a factorially designed experiment seemed appropriate. A complete factorial experiment is one in which all combinations of all the levels of all the factors are explored. Such a design enables the main effects of each factor to be estimated independently and the presence or absence of inter-

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actions (the dependence of the effect of one factor upon the levels of other factors) can be detected.

Four factors, each at two levels, were investigated—pH, temperature, bacteria, and cleaning. A complete factorial experiment would involve 16 trials. This

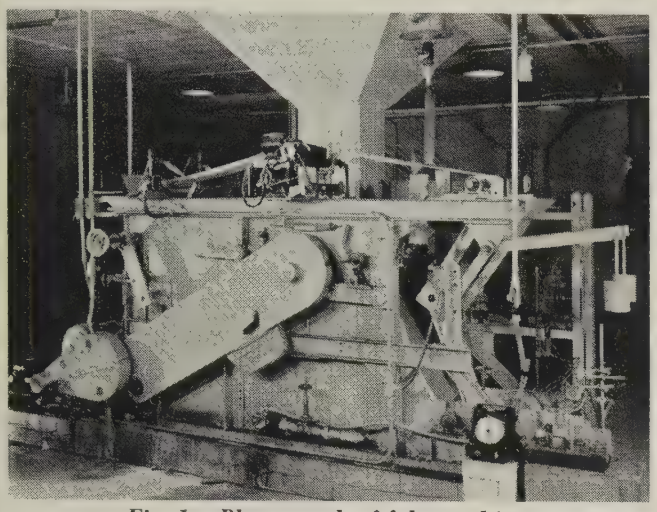

Fig. 1. Photograph of felt machine

was considered prohibitive since each trial was to require 28 days, i.e., each felt was to be run continuously on the machine for 28 days. Therefore, a fractional replicate was used—a half replicate of the complete factorial experiment. This was done on the assumption that the higher order interactions would be negligible. The experiment can be analyzed for main effects and first order interactions:

Factors	*Level-code*		*Level-code*	
A. pH	8.0	+	5.0	−
B. Temperature	35°C.	+	20°C.	−
C. Bacteria	Present	+	Absent	−
D. Cleaning	Used		Not used	−

Treatment combinations	*Factors for main effects*				*First order interaction*		
	A	*B*	*C*	*D*	*AB or CD*	*AC or BD*	*AD or BC*
(1)[a]	−	−	−	−	+	+	+
ad	+	−	−	+	−	−	+
bd	−	+	−	+	−	+	−
ab	+	+	−	−	+	−	−
cd	−	−	+	+	+	−	−
ac	+	−	+	−	−	+	−
bc	−	+	+	−	−	−	+
abcd	+	+	+	+	+	+	+

[a] Denotes treatment combination in which each factor is at its lowest level.

The signs of A, B, C, and D in the design designate the levels of the factors in each treatment combination and indicate the signs to apply to the responses in order to estimate the main effects and first-order interactions.

Environmental Factors

For temperature control, a 2000-watt immersion heater was installed in each water tank. A thermostat controlled the water temperature within ±0.5°C. For pH control, it was found that little or no adjustment was necessary at pH 8.0. The pH without adjustment was in the range of pH 7.8 to 8.4. To maintain pH 5.0, an automatic control system was installed. The standard meter of a MacBeth pH instrument was replaced with a contact meter. The contacts controlled an electronic power relay which activated a solenoid valve, thereby adding dilute hydrochloric acid solution to the water tank when needed.

The actual degradation of wool (protein fiber) by bacteria is a process of enzymolysis. Most of the more actively proteolytic organisms are species of *Bacillus*, *Pseudomonas*, and *Proteus*. During a preliminary felt run, a species of *Pseudomonas* was isolated and tentatively identified as *Ps. aeruginosa*. This organism is strongly proteolytic as shown by rapid gelatin liquefaction and Warburg respiration studies have shown it capable of breaking down wool fiber. This organism has been used as the inoculum for those felt combinations calling for the presence of bacteria. Additional nutrients in the form of yeast extract were added to the felt machine water system to accelerate the growth of bacteria. A concentrated solution of Bacto-yeast extract was prepared, sterilized, and added slowly to the machine water to give a concentration of approximately 0.01%. The system was inoculated at 2-day intervals by introducing 700 ml. of a 48-hr. culture of *Pseudomonas aeruginosa* grown in 0.1% yeast extract. Bacterial plate counts were made daily in tryptone glucose extract agar for each felt trial as an estimate of total numbers. The presence of the *Pseudomonas* inoculum is shown by production of typical pigments in the agar medium. For treatment combinations not including the presence of bacteria, the addition of yeast extract was omitted and sufficient phenylmercuric acetate (PMA) was added to maintain the bacterial population at a minimum level.

Each of the four felts in the experiment which included the use of felt cleaning, were cleaned on the machine at weekly intervals during a 28-day felt trial. Tension on the felt was relaxed, nip pressures were removed, and the machine speed was reduced to approximately 50 f.p.m. A cleaning solution (0.25% Igepal CO 630, a synthetic detergent, and 3.0% inhibited muriatic acid) was prepared and 3500 ml. contained in a gallon jug was sprayed on the top of the felt using a DDT applicator. This spraying operation required approximately 3 min. After spraying, the felt was allowed to run 2 min. and was then rinsed for 2 min. by hosing with clear water. The felt was again sprayed with 3500 ml. cleaning solution, allowed to run 2 min. and given a final thorough rinse. For those felts including the presence of bacteria, the water in the tanks was pumped into a 55-gal. drum to be drained back into the machine tanks on completion of the cleaning procedure.

Measurements of drainage rate and felt thickness (bulk) were made before and after each complete cleaning procedure. Tension and nip pressures were reapplied to the felt prior to these tests after cleaning. At the 14- and 28-day intervals, warp threads (for tensile strength tests and microscopical examination) were extracted before and after cleaning whereas at 7- and 21-day intervals, threads were taken only before the cleaning procedure.

Criteria for Evaluating Felt Changes

Tensile Strength. Wet tensile strength determinations were made on both fabric and single thread

Table I. Treatment Combinations and Factor Levels for the Eight Experimental Felts

Felt no.	Treatment combination	Factor level- pH	Temperature, °C.	Bacteria	Cleaning
1	(1)	5.0	20	Absent	Not used
2	ad	8.0	20	Absent	Used
3	bd	5.0	35	Absent	Used
4	ab	8.0	35	Absent	Not used
5	cd	5.0	20	Present	Used
6	ac	8.0	20	Present	Not used
7	bc	5.0	35	Present	Not used
8	abcd	8.0	35	Present	Used

samples to follow the loss in strength of the felt during the 28-day test run. Wet tensile values were obtained by soaking each sample in distilled water for 3 hr. prior to the strength determination. Strips were cut for the fabric tensile tests having 20 threads per strip. These strips, 8 to 10 in. long, were cut in both warp and fill directions from a control felt (unused) and from each test felt after the 28-day test run. The tensile strengths of warp and fill threads were determined for the control felt and for each felt after machine exposure of 28 days. Also, during a felt trial, approximately six threads in the warp direction were removed at the end of the first, second, and third weeks. This was done by carefully making three 6-in. cuts between warp threads in widely spaced sections of the felt and removing one warp thread from each side of a cut. Preliminary tests showed no detrimental effects from such a procedure; however, removal of fill threads caused felt failure within a short period of time.

Microscopical Examination. A staining method devised by Shema and Appling (*9*) was used to examine wool fibers for the degree of bacterial degradation. The warp threads removed for tensile strength tests

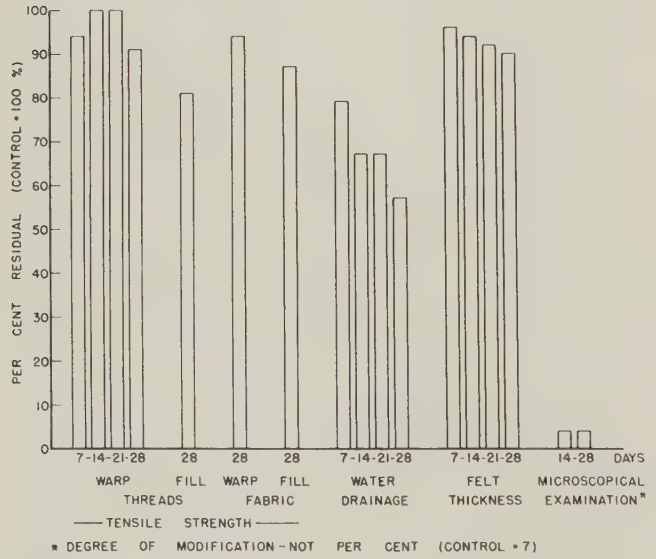

Fig. 2. Felt no. 1—treatment combination (1)

were also used for this purpose. The threads were separated into individual fibers approximately 2 to 3 mm. in length. The fibers were washed in distilled water, blotted, and immersed in a 1% solution of aqueous safranin for 1 min. After staining, the fibers were again washed with distilled water, blotted, dehydrated with diaphane solvent, and mounted on a microscope slide in colorless diaphane. The degree of bacterial damage to the fibers is shown by the extent to which the fibers adsorb the safranin dye. Normal undamaged wool fibers do not adsorb the dye whereas bacterially damaged fibers are readily stained. In

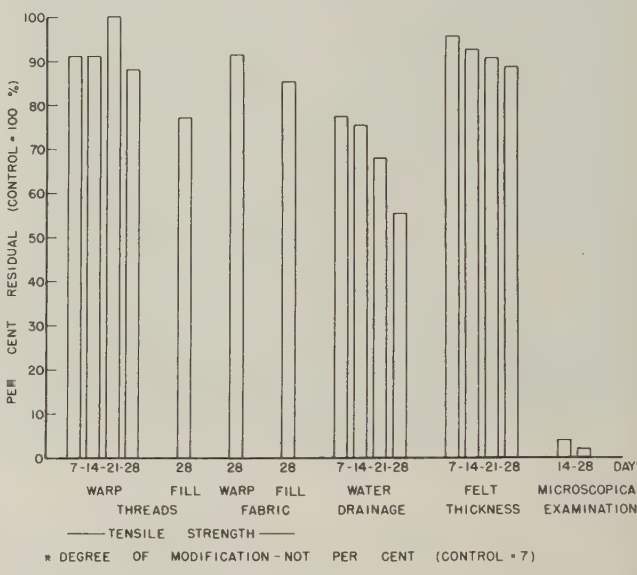

Fig. 3. Felt no. 2—treatment combination ad

addition, wool fibers which have undergone considerable bacterial damage can also be recognized microscopically by characteristic brushlike ends and the presence of free cortical cells. For an estimate of the degree of bacterial damage, a large number of fibers were counted and each classified as to the degree of damage (undamaged, slightly damaged, severely damaged). The percentage of fibers in each of these classes was determined and a degree of modification calculated.

Water Drainage. Water drainage rates were determined as an estimate of the degree of plugging. Drainage rates were measured before and at the end of each trial and at weekly intervals throughout. An apparatus was used consisting of a glass column mounted in a brass fitting which could be clamped on the felt (see Fig. 1). A reservoir with a measuring gage attached was mounted above the felt to maintain a constant water level (33 cm.) in the glass column. The area defined by the glass column is 2.57 sq. cm. and the drainage rate is determined by the time required for a measured amount of water (usually 5 l.) to pass through this area. Normally ten replicate measurements were made at different areas along the felt while the felt was under standard tension.

Felt Thickness (Bulk). Measurements of felt thickness were made as an estimate of the degree of compactness. Water drainage rates may be influenced by the degree of compactness of the felt; therefore, decreased drainage rates could be erroneously construed as due to plugging. Felt thickness measurements were determined with a Cady automatic micrometer, an instrument used to measure the thickness of paper according to TAPPI standards. The measurements were made at 20 different places along the felt at the start of a felt trial and at weekyl intervals thereafter.

EXPERIMENTAL RESULTS AND STATISTICAL ANALYSIS

In the statistical analysis of the data of drainage rate, tensile strength, etc., the effects due to seven sources of variation—four main effects and three 2-factor interactions—were calculated by use of the signs (+ or −) in the experiment design. The signs were applied to the means of the responses for each treatment combination to determine total effects. The sum of squares for each effect was calculated by squaring the total effect and dividing by the number of values (*8*) which make up the effect. Each sum of squares represents one degree of freedom and therefore equals the mean square. This procedure constitutes an analysis of variance and the mean squares are tested for significance by the F-test.

In an experiment of this type where no prior estimate of the error variance is available it is necessary to derive the error term from the experiment; however, since each treatment was tested only once no internal estimate of error variance was available. In such cases some or all of the higher order interactions (usually three to four factor interactions) are combined for an estimate of the error variance. Therefore, in this experiment, most two-factor interactions were assumed to be negligible and were combined as the only available estimate of an error term.

The replicate observations of tensile strength, bulk, and ash content were subjected to the standard analysis of variance procedure in order to determine least significant differences between means. *Y* values were used as the test of significance.

Seven of the eight experimental felts ran continuously for 28 days on the machine and data were collected at weekly intervals during the test runs. However, felt no. 8 or treatment combination abcd (see Table I) failed to complete the 28-day period. Severe raveling of the edge running against the felt guide was encountered after about 7 days and this condition progressed until the felt would no longer operate on the machine after 13 days. This occurred in spite of measures taken to curtail the raveling. Therefore, data of drainage are lacking for this felt after 7 days and no tensile strength data were obtained at 21 and 28 days.

Table II. Tensile Strength Data

Felt no.	Tensile strength, lb. — Warp threads 0 days	Warp threads 7 days	Warp threads 14 days	Warp threads 21 days	Warp threads 28 days	Fill threads 0 days	Fill threads 28 days	Warp fabric 0 days	Warp fabric 28 days	Fill fabric 0 days	Fill fabric 28 days
1	3.3	3.1	3.6	3.4	3.0	2.6	2.1	68.1	64.1	49.5	43.3
2	3.3	3.0	2.8 3.1[a]	3.3	2.8 2.9[a]	2.6	2.0	68.1	61.7	49.5	42.3
3	3.3	3.0	3.1 2.5[a]	2.3	2.7	2.6	1.9	68.1	63.5	49.5	45.2
4	3.3	3.3	2.7	2.5	2.2	2.6	1.5	68.1	42.6	49.5	28.3
5	3.3	2.8	3.0 2.9[a]	3.0	3.1 3.0[a]	2.6	2.1	68.1	64.0	49.5	42.3
6	3.3	2.5	1.2	0.7	0.5	2.6	0.6	68.1	16.9	49.5	15.9
7	3.3	3.1	3.3	3.5	2.7	2.6	2.1	68.1	63.0	49.5	45.7
8	3.3	0.6	0.8[b]			2.6	0.5[b]	68.1	20.3[b]	49.5	8.9[b]

[a] After cleaning. [b] 13-day values.

Least significant differences:

	Y_{05}	Y_{01}
Warp threads	1.65	1.84 (0.35 and 0.41, 0 and 28 days only)
Fill threads	0.31	0.36
Warp fabric	2.86	5.62
Fill fabric	4.63	5.35

Tensile Strength

Table II presents the wet-tensile strength data of warp and fill threads and fabric strips. The values, expressed in pounds, are means of several observations. Least significant differences according to the Y-test

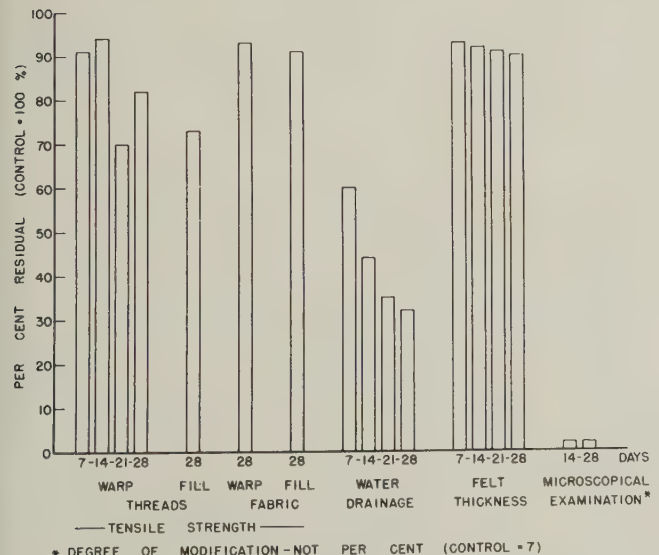

Fig. 4. Felt no. 3—treatment combination bd

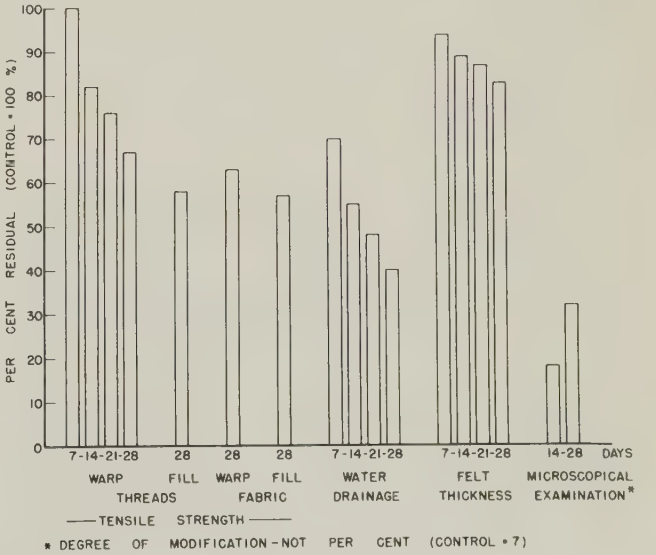

Fig. 5. Felt no. 4—treatment combination ab

Table III. Analysis of Variance of Tensile Strength Data

Source of variation	Degrees of freedom	Mean square: Warp threads	Fill threads	Warp fabric	Fill fabric
Main effects:					
pH (A)	1	3.125[b]	1.620[b]	1598.95[b]	822.15[b]
Temperature (B)	1	0.125[a]	0.080[a]	37.41[a]	30.81[a]
Bacteria (C)	1	1.805[c]	0.605[c]	572.91[c]	267.96[c]
Cleaning (D)	1	0.125[a]	0.005[a]	65.55[a]	3.78[a]
Interactions:					
AB, CD	1	0.008[a]	0.020[a]	24.85[a]	86.46[a]
AC, BD	1	1.805[c]	0.845[b]	552.78[c]	256.51[c]
AD, BC	1	0.125[a]	0.045[a]	61.05[a]	9.03[a]
Error	4	0.096	0.038	47.22	32.52

[a] Mean squares combined for error term.
[b] Significant at 1% level.
[c] Significant at 5% level.

are high for warp threads when data collected at 7, 14, and 21 days are included in the analysis. This is due to sampling techniques where some threads were probably damaged on removal from the felt and to the necessity of sampling only six threads. The larger sample sizes taken from the control felt and from each experimental felt at the end of each trial results in a more sensitive test and the Y values become smaller. Several significant differences are observed by the Y-test in the tensile strength data. The lower values for felts ac and abcd are highly significant. Treatment combination ab (pH 8.0, temperature 35°C., bacteria absent, cleaning not used) also shows significantly lower tensile strength. This is believed due to bacteria present in the water system not affected by the level of phenylmercuric acetate present. Apparently, at the favorable conditions of pH and temperature, sufficient proteolytic bacteria were present to cause some damage even though no inoculum was used and no additional nutrients were furnished. The tensile

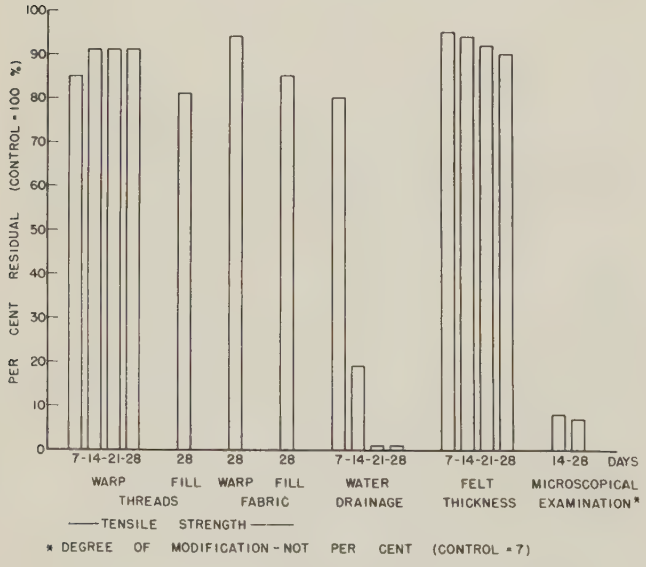

Fig. 6. Felt no. 5—treatment combination cd

strength data are also presented in Figs. 2 to 9 as the per cent strength retained by the felts with a control representing 100%.

The analyses of variance of the tensile strength data are presented in Table III. In these analyses the 13-day values for treatment combination abcd were used, since, as pointed out above, this felt failed to complete the 28-day period. It can be assumed that the tensile strength of this felt would have become progressively lower and these lower values would merely increase the significance of those factors indicated as significant in the analysis.

The statistical analyses clearly indicate that pH and bacteria influenced the tensile strength results and that the interaction of these two factors is probably sig-

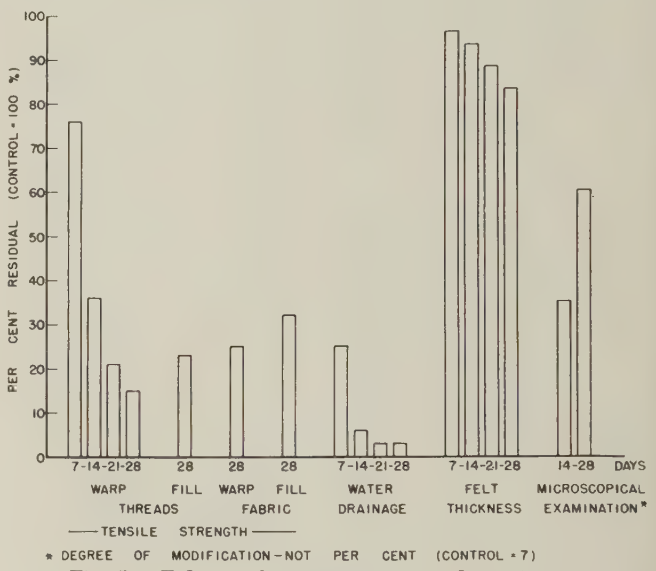

Fig. 7. Felt no. 6—treatment combination ac

nificant. At a pH of about 5.0 no tensile losses were observed in the presence of absence of bacteria. However, at a pH of about 8.0, significantly lower tensile strengths were found when a bacterial inoculum was used and additional nutrients were furnished.

The effects of temperature and cleaning were found to be negligible in the statistical analyses.

Microscopical Examination

The data obtained from a microscopical examination of fibers from the eight experimental felts are presented in Table IV and Figs. 2 to 9. Each fiber when examined was placed in a class according to the degree of bacterial damage the fiber had undergone. Four classes were used—undamaged (0), slightly damaged ($^1/_3$), moderately damaged ($^2/_3$), and severely damaged (1). The degree of modification is calculated by the following formula:

$$\text{Degree of modification} = (n_1 \times 1) + (n_2 \times {}^2/_3) + (n_3 \times {}^1/_3)$$

where

n_1 = fibers severely damaged, %.
n_2 = fibers moderately damaged, %.
n_3 = fibers slightly damaged, %.

Table IV. Microscopical Examination of Fibers

Felt no.	Degree of modification: 0 days	7 days	14 days	21 days	28 days
1	7	..	4	..	4
2	7	5	4	..	2
3	7	2	2	..	2
4	7	8	18	18	32
5	7	4	8	..	7
6	7	19	35	41	60
7	7	3	6	9	12
8	7	50	86	..	..

It is readily seen that three felts—no. 4, no. 6, and no. 8—were found to be damaged bacteriologically. Felt no. 4, as indicated in the tensile strength analysis, shows degradation even though no bacteria are indicated. Again, this is probably due to proteolytic bacterial growth at the low level of PMA and at the favorable conditions of pH and temperature.

The analysis of variance, Table V, indicates that

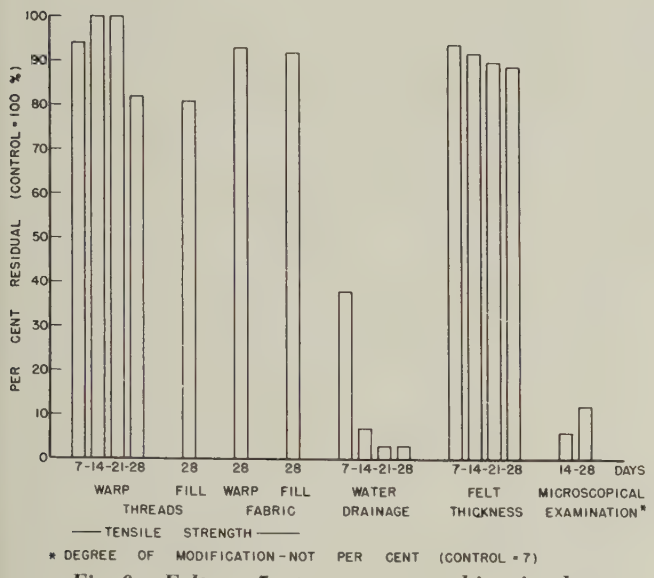

Fig. 8. Felt no. 7—treatment combination bc

proteolytic bacteria at pH 8 resulted in appreciable felt deterioration. As was the case for tensile strength, the interaction probably exists between pH and bacteria, i.e., the effect of bacteria depends on the level of pH.

Drainage Rates

Table VI contains the drainage rate data obtained from the eight experimental felts. The results are represented graphically in Figs. 2 to 9. For the statistical analysis presented in Table VII, the data (milliliters per minute) were calculated as proportions of the original drainage rate for each felt, i.e., the per cent loss in porosity was determined at the end of each week based on the initial drainage rate for each treatment combination. These data (percentages) were transformed to radians in order to completely normalize the data.

On the basis of the drainage rate data as a whole it

Table V. Analysis of Variance
(Microscopical examination of fibers)

Source of variation	*Degrees of freedom*	*Mean square* — *14 days*	*28 days*
Main effects:			
pH (A)	1	1891.1[c]	3003.1[b]
Temperature (B)	1	465.1	436.0
Bacteria (C)	1	1431.1[c]	1953.1[c]
Cleaning (D)	1	171.1[a]	15.1[a]
Interactions:			
AB, CD	1	595.1[a]	351.1[a]
AC, BD	1	1035.1[d]	1225.1[d]
AD, BC	1	171.1[a]	1.1[a]
Error	6	217.4	217.4

[a] Mean squares combined for error term.
[b] Significant at 1% level.
[c] Significant at 5% level.
[d] Significant at 10% level.

was assumed that treatment combination abcd (pH 8.0, temperature 35°C., bacteria present, cleaning used) which failed after 13 days' machine exposure time would exhibit drainage rate losses at 14, 21, and 28 days comparable to treatment combinations cd, ac, and bc. Therefore, for the purposes of the statistical analysis, felt abcd was assigned drainage rate losses of 95% at 14 days and 99% at 21 and 28 days.

According to the analysis of variance, Table VII, the effect of factor C (bacteria) is highly significant (1% level). The presence is shown by a greater degree of plugging where bacteria are present in the water system. All other main effects and interactions were statistically insignificant. The data indicate that

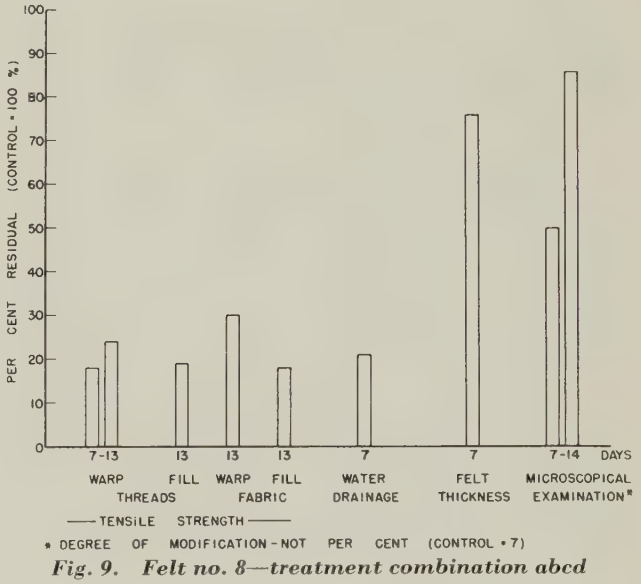

Fig. 9. Felt no. 8—treatment combination abcd

Table VI. Drainage Rate Data

Felt no.	*0 days, ml./min.*	*7 days, ml./min.*	*%[a]*	*14 days, ml./min.*	*%*	*21 days, ml./min.*	*%*	*28 days, ml./min.*	*%*
1	8,979	7090	21.0	6029	32.9	5994	33.2	5094	43.3
2	7,608	5849	23.1	5699	25.1	4910	35.5	4182	45.0
		6995[b]	8.1	5801[b]	23.8	4894[b]	35.7	4426[b]	41.8
3	10,567	6378	39.6	4582	56.1	3711	64.9	3423	67.6
		6429[b]	39.2	4483[b]	57.6	3987[b]	62.3	3986[b]	62.3
4	8,975	6234	30.5	4933	45.0	4343	51.6	3509	60.1
5	8,010	6376	20.4	1548	80.7	110	98.6	44	99.5
		6125[b]	23.5	1836[b]	77.1	346[b]	95.7	68[b]	99.2
6	7,284	1837	74.8	451	93.8	248	96.6	217	97.0
7	7,789	2975	61.8	511	93.3	170	97.8	204	97.4
8	11,020	2309	79.0	...	...	...	...	...	...
		2542[b]	76.9	...	...	...	...	...	...

[a] Percentages were calculated as the per cent loss from the original drainage rate at 0 days for each treatment combination.
[b] Drainage rate after cleaning.

temperature influenced drainage rates in that plugging tended to be somewhat greater at 35°C.

Felt Thickness (Bulk)

The data for felt thickness are presented in Table VIII and Figs. 2 to 9. Least significant differences by the Y-test show relatively great decreases in bulk for felts ab, ac, and abcd. These are also the felts which were deteriorated due to bacteria as shown by tensile strength losses and microscopical examination of fibers. An analysis of variance of the thickness data proved to be inconclusive, i.e., no real significance could be assigned to any of the effects. However, pH, temperature, and bacteria appear to influence the measurement, and probable interactions of pH and temperature and pH and bacteria are indicated.

Table VII. Analysis of Variance Drainage Rates

Source of variation	*Degrees of freedom*	*Mean square* 7 days	14 days	21 days	28 days
Main effects:					
pH (A)	1	0.0617	0.0003	0.0022	0.0005
Temperature (B)	1	0.0779	0.0529	0.0338	0.0205
Bacteria (C)	1	0.1987	0.7051[b]	0.9579[b]	0.7372[b]
Cleaning (D)	1	0.0096[a]	0.0024[a]	0.0098[a]	0.0079[a]
Interactions:					
AB, CD	1	0.0330[a]	0.0042[a]	0.0003[a]	0.0002[a]
AC, BD	1	0.0886[a]	0.0247[a]	0.0006[a]	0.0005[a]
AD, BC	1	0.0046[a]	0.0072[a]	0.0259[a]	0.0205[a]
Error	16	0.0150	0.0150	0.0150	0.0150

[a] Mean squares combined for an error variance of 0.015 and 16 degrees of freedom.
[b] Highly significant.

Table VIII. Bulk or Thickness Data

Felt no.	*Bulk, 1/1000 in.* 0 days	7 days	14 days	21 days	28 days
1	65.9	63.5	61.8	60.4	59.5
2	67.9	64.3	62.7	61.4	60.1
		63.5[a]	62.0[a]	61.0[a]	60.1[a]
3	66.7	62.3	61.4	60.9	60.2
		62.0[a]	61.0[a]	60.6[a]	60.5[a]
4	66.3	62.3	58.8	57.6	55.2
5	67.1	63.9	62.9	62.0	60.3
		63.7[a]	62.7[a]	61.1[a]	60.3[a]
6	67.1	64.7	62.4	59.2	55.8
7	67.1	63.1	61.4	60.5	59.5
8	67.8	51.5	...	...	...
		52.0[a]	...	...	...

[a] Bulk after cleaning procedure.
[b] Least significant differences: $Y_{05} = 1.24$; $Y_{01} = 1.38$.

Measurements of bulk were made to indicate the the degree of felt compaction and whether compaction would tend to influence drainage rates. In addition, it was believed that felt thickness would provide some information as to felt wear. It was found that no direct correlation exists between felt thickness and plugging in this experiment, i.e., some felts which were plugged showed no greater losses in bulk than did others which were not plugged. However, felts showing considerable bacterial damage also exhibited appreciable losses in felt thickness. Apparently, as bacterial degradation of the woolen fibers progressed, the wool lost its resiliency and compaction resulted.

CONCLUSIONS

In this experiment, the statistical analyses have shown that bacteria not only deteriorated woolen felt due to enzymolysis at pH values of about 8.0 but that bacteria significantly influenced the degree of felt plugging. This plugging in the presence of bacteria was observed at both levels of pH and both levels of temperature. The types of bacteria prevalent in the machine water system at pH 8.0 were obviously proteolytic whereas those prevalent at pH 5.0 were not capable of wool breakdown. (The optimum pH range of most proteolytic bacteria is pH 7.5 to 8.5.) At both pH levels, however, plugging was observed. It was not determined in what way the presence of bacteria contributed to plugging in these tests. French (*6*) in his work on plugging of felts has suggested that bacteria are probably not solely responsible for plugging, but the presence of bacteria may be important in entrapping wool scales and other particles.

According to the statistical analyses, the deterioration of woolen felts due to bacterial activity was not significantly influenced by the temperature range used in this experiment. The optimum temperature range of proteolytic bacteria is 30 to 37°C. In this experiment, considerable bacterial damage was observed at 20°C. and pH 8.0. It should be noted, however, that felt abcd (pH 8.0, temperature 35°C., bacteria present) failed after about 13 days whereas felt ac (pH 8, temperature 20°C., bacteria present) completed the 28-day trial period. This result indicates that temperature influenced the rate of bacterial deterioration of the felts more than the statistical analysis of the data shows.

The results indicate that the cleaning procedure used in these tests had no significant effect on the rate of bacterial deterioration of wool. In commercial use, cleaning would normally be expected to improve the porosity of a removal of plugging materials such as pitch, rosin, alum floc, etc. However, in this experiment the observed decreased drainage rates were apparently due to materials not affected by the cleaning solution used. It is believed that the experiment could be considered a complete factorial design of three factors (pH, temperature, and bacteria) with each factor at two levels since cleaning; the fourth factor, showed no appreciable effects on any of the criteria used to evaluate felt changes. The effects of cleaning (D) would then become designated as a three-factor interaction (ABC) and, being negligible, would be included in the experimental error. In the statistical analyses the effect of cleaning (D) was used as part of the error term.

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Special Starches for Corrugating

B. L. SCALLET and E. A. SOWELL

Although unmodified cornstarch is the principal adhesive used in manufacture of corrugated board, there has been in recent years a trend toward development of special starch-based adhesives possessing properties especially valuable for certain phases of corrugator operation. These include: high viscosity starches, made by means of cross-linking reagents, which can produce strong bonds efficiently and which have increased stability against shear; low viscosity starches, produced by acid treatment, which have greater penetration as well as increased viscosity stability; premixed adhesives, which offer the advantage of simpler preparation, for use under alkaline conditions for normal uses or under acid conditions for the production of board for glass packaging; improved water-resistant adhesives for weatherproof boxes.

THE original patents describing the starch adhesive process now in use by most manufacturers of corrugated board disclosed many variations in paste make-up (*1–3*). Since the acceptance of this process by the corrugating industry, unmodified cornstarch has become its major adhesive, due primarily to its availability and uniform quality. Although other starches such as those from tapioca and wheat are used, they are of somewhat less importance, and the discussion here will involve only products from cornstarch.

The many factors encountered in corrugating practice such as diversity of machine operations, variations in board specifications, and demand for better production rates at lower cost have in recent years stimulated the development of special starches as an aid in the solution of these problems. Some of the products are for use in either or both the primary and secondary mixers. Others are premixed dry-blended adhesives requiring simpler equipment for paste preparation. In addition to these there are special adhesives used for the production of weatherproof boxes. Many of these special starches are being offered to the corrugator, and the following discussion will describe briefly their general method of manufacture and application.

HIGH VISCOSITY STARCHES

Some of the special products now being offered are the high viscosity starches. These, as the name implies, produce a heavier-bodied paste than unmodified cornstarch and because of this are sometimes called "thicker" or "thick-thick boiling" starches. A number of procedures have been used for their manufacture, and they have been known in starch technology for many years. Today, the principal methods for producing this type of starch involve the use of cross-linking reagents. These reagents are said to be bifunctional or polyfunctional in that they have two or more reactive groups. With starch these compounds form strong chemical bridges between the molecules which make up the intertwined molecular network of the granule. These bridges impart additional strength to the network organization, making it more resistant to disruption. If the number of cross-links introduced is high, the granule network is so strengthened that the granules will not swell in boiling water. On the other hand, when relatively few cross-links are introduced, the network can expand tremendously without disruption because of the additional tie points between molecules brought about by cross-linking. By controlling the degree of reaction, different viscosity effects can be obtained, resulting in starches which vary in a wide range—from those that cannot be pasted to those having viscosities several times that of unmodified starch. Figure 1 gives viscosity curves, obtained in the Corn Industries viscometer (*4*), for a typical set of starches produced by varying the degree of cross-linking. The curves show the changes in viscosity of 5% starch-water pastes as cooking proceeds.

Increasing the amount of cross-linking results first in increased viscosity, then in reduced viscosity.

Many different agents can be used to create these effects. Dimethylol urea and its polymers (*5*), melamine-formaldehyde (*5*), epichlorohydrin (*6*), trichloro-s-triazine (*7*), formaldehyde (*8*), sodium stannate (*9*), and phosphorus oxychloride (*10*) are examples of some of the substances that have been used for producing high viscosity starches. The proper choice of reagent as well as reaction conditions is quite important, as in many cases undesirable properties may be introduced. For example, some reactions are difficult to control, resulting in a wide variation of viscosity which of course is not desirable for corrugating operations. With other reagents, some insoluble starch clusters are formed during the reactions which can interfere with proper dispersion and paste circulation in the corrugating plant.

Certain reagents and reaction conditions may improve an important property, viscosity stability. Some thick-thick boiling starches exhibit a high viscosity for a short period, only to break down upon further cooking. Others show viscosities which increase gradually during cooking, while some reach a high viscosity level and maintain it for hours.

In addition to viscosity effects, the cross-linking agents may produce changes in tackiness or stringiness of the paste. Thus, one type of thick-thick boiling starch may be more advantageous than another, depending on the conditions existing in a particular corrugating plant. Factors such as type and weight of liners and medium, machine speeds, and paste handling variations may be important here. From the theoretical standpoint, these starches should have two practical advantages over unmodified starch: (1) the same viscosity effects can be obtained with smaller amounts of thick-thick boiling starches, and (2) the bond strength should be greater. In support of the latter idea, it has been shown that decreasing the molecular size or com-

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plexity of starch (as by acid hydrolysis) results in lowered bond strength (*11*). Extensive hydrolysis results in sirups, ultimately dextrose, which have little or no bonding strength. Conversely, it can be reasoned that an increase in the size and complexity of the molecule, which results from cross-linking, should give stronger bonds than are obtained with unmodified starch.

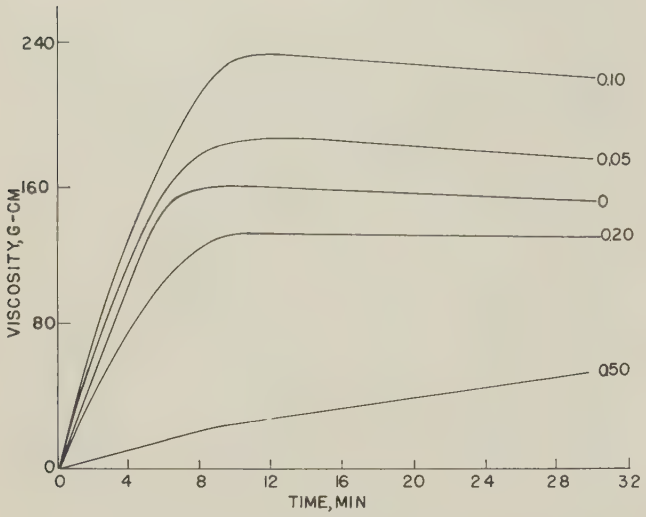

Fig. 1. Viscosity curves for starches having different degrees of cross-linking; figures from 0 to 0.50 represent quantity of reagent used; all curves are for 5% solids, and the origin represents beginning of pasting

As the choice of reagent plays such an important role in producing variations in thick-thick boiling starches, it is to be expected that the currently manufactured products will differ from each other to some extent. In some uses these differences are of minor importance, whereas in others, adhesive formulations must be changed to insure satisfactory operation. Figure 2 shows the different viscosity curves obtained with several thick-thick boiling starches available today. Although they were obtained with starch-water systems, it is a reasonable assumption that differences would also occur in corrugating pastes.

One of the principal applications of thick-thick boiling starches has been in the double backer formulation of a dual viscosity system. As the double backer paste is higher in viscosity, these starches are of value in carrier preparation. They have also been used in the lower mixer in this instance, where their higher water absorption prevents excessive adhesive migration. This of course is reflected in a lower paste usage and more efficient double backer bonding. In addition to their use in the double backer paste, some corrugators have been successful in using them for all paste make-up, effecting additional savings and eliminating the necessity for carrying more than one type of starch in stock. Obviously, changes in formulation may be necessary to obtain satisfactory results.

LOW VISCOSITY STARCHES

These starches are generally called "thin-boiling" as their pastes give lower viscosities than does unmodified starch. As used in the corrugating industry they generally are made by the acid process which consists in treating a slurry of unmodified starch with dilute mineral acid. This treatment does not change the physical form of the granule, but it does result in random degradation and weakening of the molecular network within the granule. By controlling the amount of acid, temperature, and reaction time a continuous series of lower viscosity starches can be produced (see Fig. 3).

Only those starches which have been but slightly modified are of any interest to the corrugator, since greater modification leads to loss of the suspending and adhesive qualities necessary in corrugating adhesives. One of the main uses for the slightly modified starches is for the preparation of carriers. As these starches have weak internal structure, their granules disintegrate more easily upon cooking and this results in achieving a more completely pasted starch. Obviously, to obtain a viscosity comparable to that of unmodified starch, the thin-boiling type must be used at a higher solids level.

One of the problems sometimes associated with the carrier is the maintenance of a uniform viscosity under the stress of agitation, heat, and alkali. The high degree of shear obtained through mixing, pumping, and circulating the paste will, in some instances, result in viscosity breakdown if a carrier is not prepared properly with unmodified starch. This is due to the fact that there may be many highly swollen, elastic granules which have not been thoroughly dispersed. The use of a more easily dispersed thin boiling starch therefore enhances the viscosity stability. In effect, the pretreatment of the starch has already accomplished the breakdown which would otherwise occur because of shear.

Frequently, these low viscosity starches are used in the upper as well as the lower mixer for preparing a dual viscosity single facer formulation. In this case, because of the modification, more penetration and a faster tack are obtained.

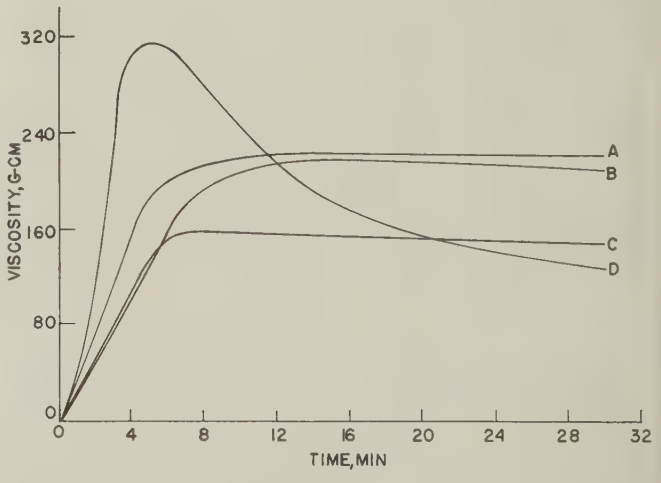

Fig. 2. Viscosity curves of commercial thick-thick boiling starches (C is unmodified starch)

PREMIXED CORRUGATING ADHESIVES

The standard double-mixer system currently in use by most corrugators is expensive with respect to equipment cost and requires expert supervision to ensure sat-

isfactory adhesive preparation. However, it enables the producer to use unmodified starch, which keeps the cost per square foot low. As an aid to those manufacturers not equipped for double-mixer operation, or for those who prefer simplicity of operation, the premixed corrugating adhesives have been developed. These products are carefully compounded blends of uncooked starch and a water-dispersible suspending agent to act as a carrier. Pregelatinized starch or a natural gum is generally used for the latter. The corrugator simply adds the required amount of the premix to warm water and agitates until thorough hydration and blending of the components occur. Some products may be used with alkali and borax as a standard corrugating adhesive while others have been compounded to give good adhesion under neutral or acidic conditions. These are used in the manufacture of corrugated board for the packaging of glass or other products whose surfaces may be affected by the presence of alkali. In general, the natural gums cannot be used with alkali because of viscosity breakdown.

Although these blends are convenient and require very little pastemaking equipment, their use usually results in greater adhesive cost per square foot of board because of the prepasting and blending done by the starch manufacturer.

WATER-RESISTANT CORRUGATING ADHESIVES

The imparting of water-resistance to starch-based corrugating adhesives is not new to the corrugating industry. For over 15 years much research and study has been given to this problem (*12, 13*). The difficulties involved can be readily understood when it is considered that starch must combine with water for adhesion to occur. Any method of imparting water-resistance must be timed to exert its effect during or after the initial adhesion. Much of the work in this field has involved the addition of various chemicals by the corrugating manufacturer to the paste. Generally these additives

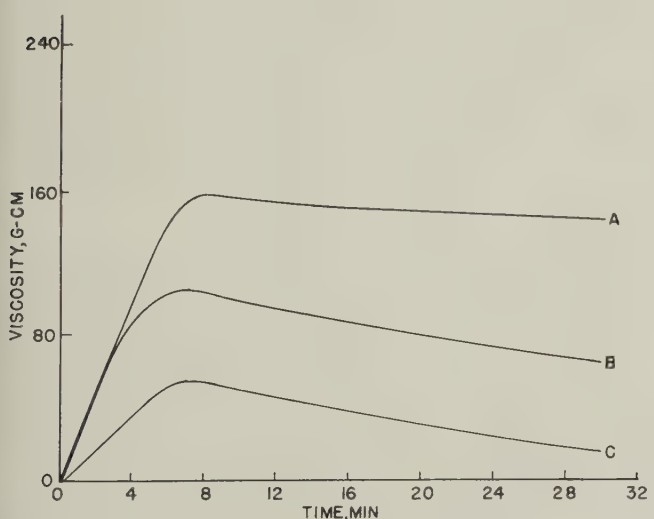

Fig. 3. Viscosity curves for thin-boiling starches (A, unmodified; B, slightly modified; C, extensively modified)

are thermosetting resin precondensates, which, under the proper conditions of pH and temperature, react with the starch to reduce the rehydration properties of the dried adhesive film. Although the exact chemistry of this mechanism is not known, it has been proposed (*14*) that the resin cross-links or blocks those groups in the starch molecule which give it an affinity for water (see Fig. 4). Most of these resins are of the urea-formaldehyde and melamine-formaldehyde types, which require acidic conditions of the paste for the reaction to occur.

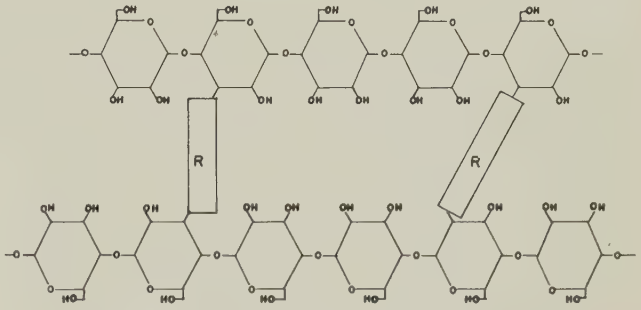

Fig. 4. Cross-linking of starch molecules

The compounding of the adhesives necessitates careful control, the paste life is short, and the machines must be operated at slow speeds and with great care. Several years ago, further progress was made when the starch manufacturer preadded alkaline-setting resins such as those of the ketone-aldehyde and resorcinol-aldehyde types. However, water-resistance of the bond was not as good as that obtained with the acid-catalyzed resins.

Recently, several new water-resistant adhesives for use under alkaline conditions have been introduced. Some of these are one-bag mixes containing the starch, carrier, resin, and catalyst. These are merely added to warm water and mixed. Additional caustic or borax may be used as necessary to adjust viscosity or paste characteristics. The other type of alkaline adhesive currently available is designed for the double-mixer system. In this product the carrier starch contains the resin precursor and it is only necessary to add a source of formaldehyde to the raw starch in the lower mixer (*15*). Resorcinol is used as the resin precursor.

With these modern adhesives, many of the former difficulties have been eliminated, and production of water-resistant corrugated board can now be carried on conveniently and at a rapid rate.

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The Carbonyl Group and Brightness Reversion

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Bleached kraft, bleached sulphite, chemical-grade cotton linters, and isolated hemicellulose fractions were oxidized with periodate to various copper numbers, and oven aged for 1 hr. at 105°C. For copper numbers between 5 and 50, brightness reversion did not increase with copper number. It was concluded that the position of carbonyl groups and the nature and fine structure of the material probably greatly influence the possibility of carbonyl condensation reactions and, hence, the amount of brightness reversion.

Brightness reversion of bleached pulps is a major problem (*1*). It causes significant cost increases and undesirable indeterminate pulp quality effects. The problem has received considerable study, yet remains largely unsolved and little understood. Undoubtedly, many factors and a number of different mechanisms contribute to reversion.

Rollinson (*2*) showed that bleaching conditions and interstage washing practice have a marked effect on the tendency of a bleached pulp to lose brightness when heated. He showed the coloring material associated with reversion to be carbohydrate, thus indicating residual lignin was probably not a primary cause of reversion in bleached pulps. Chadeyron (*3*) concluded that the condensation of carbonyl groups formed during bleaching was the main cause of heat reversion. Giertz and McPherson (*4*) agreed with this view, and extracted colored carbohydrate material of probable hemicellulosic origin from heat-reverted pulp with lithium hydroxide. Rapson and Hakim (*5*) have given a review of the color reversion problem and have shown that heat reversion can be greatly reduced if carbonyl was oxidized to carboxyl with chlorine dioxide, or reduced to hydroxyl with sodium borohydride. These several studies support a growing body of evidence associating both carbonyl content and lower molecular weight carbohydrate fractions with heat reversion of bleached pulps. This present study sought further information on the role of carbonyl groups in the heat-induced color reversion of bleached pulps.

EXPERIMENTAL

Preparation of Periodate Oxidized Pulps

A bleached Swedish kraft, a commercial bleached western hemlock sulphite pulp, and chemical-grade cotton linters were oxidized to various levels of copper number by periodate. Prior to oxidation, the wood pulps were soaked overnight in distilled water and then slushed for 300 counts in the British disintegrator. The pulps were oxidized at 2% consistency with 0.1 molar periodic acid solution, under conditions of constant agitation on a rotating rack, for a number of different time intervals to produce a series of products with substantially different copper numbers. The reaction mixture was unbuffered at room temperature. Initial pH of the mixture was 2.0. The reaction was carried out in the dark to minimize photochemical effects. Unconsumed periodate was washed from the pulp with distilled water.

Preparation of Periodate-Oxidized Hemicellulose

The hemicellulose material used was a mixture of the 5 and 16% KOH-extractable materials from a bleached aspen neutral sulphite pulp, obtained by the method of Wise (*6*).

Five grams of the hemicellulose were oxidized in a mixture of 125 ml. of 0.2 molar periodic acid and 125 ml. of 95% ethanol. The reaction was carried out at room temperature in Erlenmeyers wrapped with aluminum foil. A magnetic stirrer was used. The alcoholic reaction mixture permitted essentially complete (90%) recovery of the oxidized material. In earlier work using water only as the reaction medium, the recovery of the oxidized hemicellulose was quite poor (about 40%), even when large amounts of ethanol were added to the reaction mixture in an attempt to precipitate the material. After the desired reaction time, 500 ml. of 95% ethanol was added to the reaction mixture, and the precipitated hemicellulose recovered by centrifuging. It was washed four to six times with 95% ethanol to remove periodate solution, and then suspended in 80% ethanol and sulphur dioxide bubbled through the mixture to reduce any remaining sorbed periodate. The course of this reduction was followed by noting the yellow color of iodine, which if present indicated incomplete reduction. Presence of necessary excess sulphur dioxide was established from its odor. The reduction proceeded slowly, and the samples remained in the 80% ethanol overnight. They were recovered by washing twice with 250 ml. of 95% ethanol, three times with 250 ml. of absolute ethanol, and dried by washing with ether.

Determination of Carbonyl Content

Carbonyl content was taken to be approximately proportional to the copper numbers of the periodate-oxidized pulps and hemicellulose as determined by TAPPI Standard T 215 m-50. The filtering step was very tedious for the hemicellulose and was replaced by centrifuging. The cuprous oxide precipitate was dissolved in the molybdophosphoric acid solution and titrated in the presence of the hemicellulose. Comparison runs with this modified procedure gave the same copper number as the standard procedure with filtering.

Determination of Brightness

Brightness of the unoxidized and periodate-oxidized pulps was determined on standard TAPPI brightness handsheets (T 218 m-58) before and after oven aging by TAPPI standard T 217 m-48. Brightness of the

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Table I. Effect of Time at 105°C. on Reversion of Periodate-Oxidized Sulphite Pulp

Oxidation time, hr.	Copper no.	$\Delta k/s \times 10^5$ 1-hr. aging	4-hr. aging	18-hr. aging
0	1.9	786	1096	2003
0	1.9	620	1046	1651
0.08	4.3	932	1659	3337
0.75	12.2	1064	1798	3334
0.75	12.6	886	1611	3727
1.0	14.2	1109	1752	3382
2.0	16.0	1121	2049	3088
4.0	22.8	877	1642	3059
15.0	50.2	810	1588	3047

unoxidized and periodate-oxidized hemicellulose materials was determined on compacted plaques of the unaged and oven-aged powder using TAPPI standard T 646 m-54, but with a lower compacting pressure of 30 lb. total in a $1^5/_8$-in. i.d. brass tube in place of the standard 30 p.s.i.g. compacting pressure. Repeated pressing and redispersing did not affect the brightness of the powdered material. All brightness measurements were made as soon as feasible after oxidations and agings.

Induction and Characterization of Reversion

At least two important factors require definition in reversion studies. The conditions under which the measured reversion is induced and the units with which the amount of reversion are described. It is noted that no standard or generally used conditions or units exist for either.

In this study, reversion was induced by exposure in an oven at 105°C. for 1 hr. at essentially zero relative humidity, for reasons of reproducibility and convenience. It is well established that the amount of reversion increases with time—particularly at 105°C. The choice of 1 hr. aging time was made after obtaining reversion data for 1, 4, and 18 hr. at 105°C. on a periodate-oxidized commercial western hemlock bleached sulphite pulp. From this data, shown in Table I, it was concluded that the same kind of relationship between copper number and $\Delta k/s$ existed at 1 and 18 hr. aging. Above a copper number of about 4, the amount of reversion for a given aging time did not increase with copper number.

Table III. Reversion of Periodate-Oxidized Hemicellulose
(Aged 1 hr. at 105°C.)

Oxidation time, hr.	Copper no.	G.E. brightness, % Initial	Final	G.E. brightness, % ΔG.E.	$\Delta k/s \times 10^5$
0	1.3	81.1	79.4	1.7	470
0	1.3	84.5	82.7	1.8	388[a]
0.33	12.6	89.9	88.0	1.9	251
1	29.8	87.5	86.1	1.4	230
4	33.7	89.5	87.6	1.9	263
12	48.3	90.5	87.5	3.0	394

[a] Suspended in 80% ethanol, given sulphur dioxide treatment. Reaction proceeded 12 hr., giving effects of SO_2 treatment used in destroying periodate.

The amount of reversion is expressed as $\Delta k/s \times 10^5$, which is similar to the PC (Post Color) number of Giertz (*7*). The ratio of the absorption coefficient (k) to the scattering coefficient (s) was obtained from G.E. brightness measurements and the Kubelka Munk relationship, $k/s = (1 - R_\infty)^2/2R_\infty$, where R_∞ is G.E. brightness, using the tabulations of MacLaurin and Aflenzer (*8*). Limited data in this study supported the generally accepted conclusion that the scattering coefficient (s) was practically unchanged by the kind of chemical and aging treatments given the pulps. Thus, it follows that changes in k/s are essentially linearly proportional to changes in the absorption coefficient (k) and, hence, to chemical changes which cause color changes. This was the primary reason for expressing amount of reversion as $\Delta k/s$. There are real problems in obtaining k and s as separate values—particularly with materials from which sheets could not be formed. However, it is planned that continuing similar studies in these laboratories will give k and s separately, thus providing a better understanding of the optical and chemical changes associated with reversion, and for comparing the reversion of different materials on the basis of Δk only.

Tables II and III give the oxidation and reversion data for the pulps and the hemicellulose material.

DISCUSSION

Increasingly drastic periodate oxidations of the pulps and the hemicellulose material gave the same type of unexpected reversion behavior pattern, in

Table II. Reversion of Periodate-Oxidized Pulps
Aged 1 hr. at 105°C.

Material	Oxidation time, hr.	Copper no.	G.E. brightness, % Initial	Final	ΔG.E.	$\Delta k/s \times 10^5$	Alpha-cellulose, %
Sulphite pulp	0	1.8	86.1	82.9	3.2	640	85
	0	2.0	87.9	85.2	2.7	452[a]	
	1	12.4	89.1	85.8	3.3	508	
	2	15.4	89.5	85.9	3.6	541	
	4	25.6	89.2	85.9	3.3	502	
	7.5	23.5	88.7	85.7	3.0	470	
	24	46.9	87.8	84.7	3.1	534	
	32	49.9	88.5	85.0	3.5	576	
Kraft	0	1.5	88.5	86.6	1.9	290	87
	7.5	26.9	88.6	86.3	2.3	257	
	24	42.3	88.3	85.9	2.4	324	
	32	55.0	88.7	88.6	0.1	370	
Cotton linters	0	0.2	91.2	90.5	0.7	74	98
	1	9.9	91.6	90.6	1.0	125	
	2	15.5	91.7	90.6	1.1	113	
	4	22.6	89.9	88.9	1.0	126	
	8	32.3	91.3	90.2	1.1	117	
	16	52.7	91.4	90.1	1.4	139	

[a] Given 2-hr. treatment with HCl, pH 2.0, at room temperature.

that further oxidation above a relatively low copper number did not result in a parallel increase in reversion. It would be generally agreed that the periodate oxidation used in these experiments would quite selectively cleave the 2–3 bond in either the pentosan-hexosan complex of the pulps (Tables I and II) or the pentosan complex of the hemicellulose (Table III), and introduce carbonyls at the 2 and 3 positions.

These data, then, raise questions concerning possible relationships between the positions of carbonyls and their effect on reversion.

Continuing studies of such questions are going forward in these laboratories.

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An Experimental Study of Some Drier Drainage Siphons

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An experimental study has been made of the behavior of stationary and rotating drier drainage siphons under conditions exactly duplicating those in an actual paper machine. Quantitative knowledge of siphon behavior such as was obtained in this experiment is essential for the intelligent specification of drier drainage system design, sizing, and operating pressure differentials. Many aspects of siphon behavior were investigated. Of particular interest, however, are the relationships between pressure differential, condensate flow rate, blow-through steam flow rate, drier speed, and steam pressure in the high-speed range where the condensate is rimming and where, with the rotating siphon, the centrifugal force effect is of importance. This phase of the study is presented here. The flow versus pressure drop data obtained in the high-speed range can be successfully presented in a general form using the Lockhart and Martinelli type correlation for two-phase flow pressure drop modified to take into account the effect of centrifugal force in the case of the rotating siphon, and the effect of condensate velocity relative to the siphon tip in the case of the stationary siphon. This generalization renders the data more readily usable in the direct application to systems using the siphons tested. It also provided a basis for a rotating siphon design improvement which is discussed, and may be of interest for other investigations of drier drainage siphon behavior.

Drier condensate removal siphon designs and the problems encountered in their operation have advanced through various stages corresponding to the drier speeds maintained. When drier speeds were low, i.e., less than 500 f.p.m., the simple stationary siphon consisting of a relatively flexible piece of tubing projected into the drier with a suitable curve so that it reached more or less toward the bottom of the drier was commonly used. This type of siphon worked very well at the low speeds because the condensate in the drier was never rimming at these speeds. The nonrimming condensate remained in a puddle near the bottom of the drier, and this puddle could be of sufficient depth so that the siphon pipe was immersed in it, regardless of relatively large variations in the exact position of the end of the pipe with respect to the drier shell. Both the condensate puddle and the siphon pipe were stationary in space so that the removal of condensate was a simple matter of pumping water through a few feet of elevation through the curved siphon pipe. In this case the heat transfer coefficient between the steam and the inside of the drier shell surface was very high. Although a thin film of condensate is carried around with the drier shell even in a nonrimming drier, this film is very thin, and the bulk of the condensate at the bottom of the drier is adequately mixed.

When drier speeds of 700 f.p.m. and higher became used, the simple stationary siphon did not work well. If the factors involved were such as to maintain a nonrimming puddle of condensate in the drier, the power consumed by the churning puddle became appreciable. If the amount of condensate in the drier was small and if the speed was high enough, this power consumption would disappear because the condensate would rim. When the condensate is rimming, it is held against the drier shell inside surface by centrifugal force, and is all spread out over this surface in a layer of suprisingly uniform thickness, as actually measured in some of our experiments. Under some conditions, a series of spiral waves with crests a few inches apart have been observed in rimming condensate. But except as indicated by the presence of these waves and by the fact that there is a small velocity of condensate flow over the drier shell surface toward the siphon inlet, there is no measurable relative velocity, even of a cyclic type, between the condensate and the drier shell.

For a given amount of water per unit shell surface area, the condensate will make a sudden transition from the nonrimming to the rimming state as the speed is gradually increased. This rimming speed increases appreciably with increased amounts of water in the drier. If the speed of a rimming drier is gradually reduced, the rim suddenly collapses at a definite speed which is always less than the speed at which the same amount of water starts to rim. The collapsing speed is much less dependent on the amount of water in the drier. These characteristics are shown in Fig. 1, which gives the results of an experiment which was made with our 5-ft. diam. drier during a series of tests

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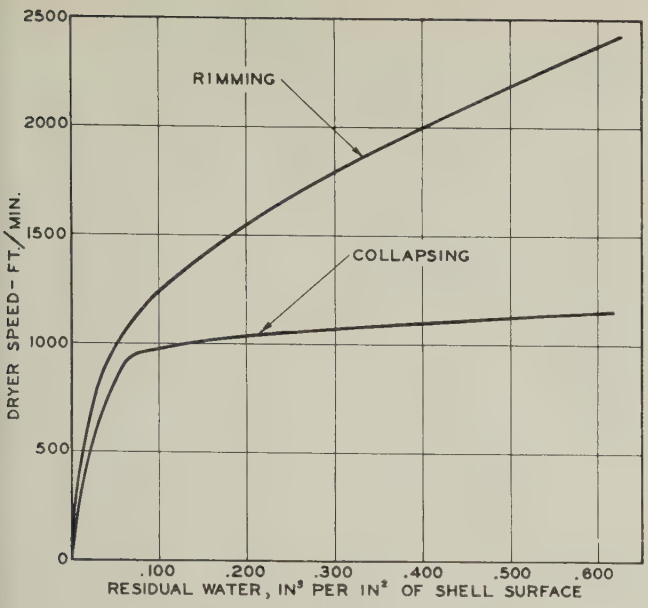


Fig. 1. Rimming and collapsing speeds for 5-ft. diam. drier with 80°F. water

with one of the heads removed. The data shown in Fig. 1 are for room temperature water. At higher temperatures such as occur in actual driers, the rimming speeds will be a little higher due to the decreased viscosity of the condensate. For a more complete study of the rimming and collapsing behavior of condensate in driers the reader is referred to the work of Robert White (*1*).

When the condensate is rimming, it may exist in a layer of appreciable thickness. This layer is an insulating layer, the thermal conductivity of water being only about one hundredth that of cast iron. Therefore it is essential, in a rimming drier, to keep the condensate layer as thin as possible. This cannot be achieved with the simple stationary siphon because the inlet end of the siphon pipe cannot be held close enough to the drier shell inside surface to pick up condensate from the thin layer desired.

The removal of condensate from driers at higher speeds without the disadvantage of either high power consumption or low heat transfer was improved by the rotating siphon developed at Beloit Iron Works in the early 1930's. This siphon is shown schematically in Figs. 2 and 3, and is referred to here as the original rotating siphon to distinguish it from the rotating siphon recently developed, which is discussed later. This original rotating siphon worked very well for either low speeds where rimming did not occur as well as for rimming condensate with drier speeds up to at least 1500 f.p.m. For these conditions, a pressure difference of 3 to 4 p.s.i. was sufficient to remove condensate at any rate of interest, and to maintain a reasonably small condensate layer or puddle as the case might be. The blow-through steam rate, with this pressure difference was not excessive, even at very low condensing rates. With the siphon rotating with the drier, it was possible with little difficulty to maintain a precise placement of the siphon inlet shoe with respect to the drier shell surface, and thus possible to achieve the low condensate layer in a rimming drier. The factors affecting this condensate layer thickness will be discussed in more detail in the following parts of this paper. When the condensate is not riming, the rotating siphon scoops water from the puddle as it moves through it and also the siphon shoe retains water picked up during its immersion in the condensate puddle which is then pumped out by a small pressure difference or at low speeds is simply drained out by gravity while the rotating siphon pipe is in the upward part of its swing.

As drier speeds increased to 2000 f.p.m. and higher, the pressure difference needed to evacuate condensate from a riming drier with the original rotating siphon increased considerably because of the centrifugal force acting on the liquid condensate in the rotating siphon pipe. In particular, if the siphon inlet is submerged in the rimming condensate layer, the centrifugal force pressure drop becomes very large at these higher speeds. As will be shown by the data to be presented, the blow-through steam varies a great deal with condensate flow rate when these higher pressure differences are maintained across the original rotating siphon. For practical reasons, this pressure difference is controlled only for a group of several driers in parallel rather than for each individual drier. The condensing rates may vary a great deal from drier to drier within such a parallel group, and also from time to time. Therefore, it is possible that the pressure difference across the group of driers may be in equilibrium with a large blow-through steam rate through some of the driers in the group while for one or more driers with larger condensing rates the blow-through rate may be very small. In some cases, this has led to some driers in a group becoming flooded, i.e., the equilibrium condensate level for those driers reaching a level such that the siphon shoe was submerged. Thus, to assure evacuation with a small condensate layer thickness for all driers in a group, it is necessary to operate the drainage system with a large pressure difference; larger for most driers than would be needed if each drier were individually controlled. With this large pressure difference, the majority of the driers in a group will have a very high blow-

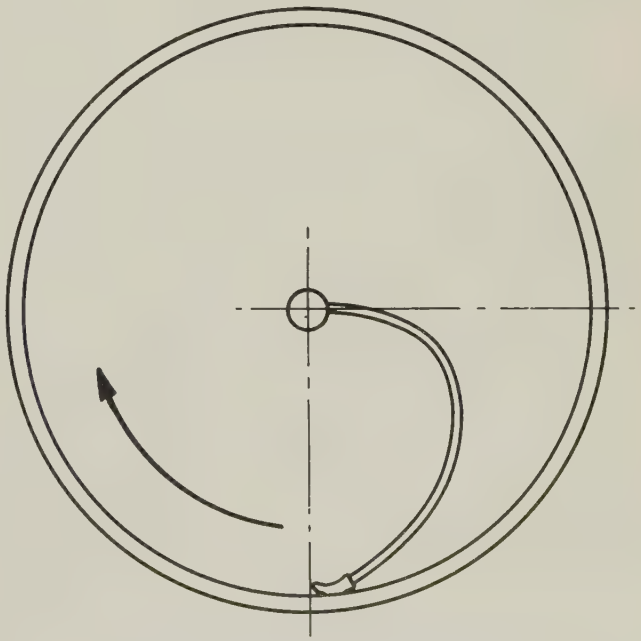


Fig. 2. Original rotating siphon

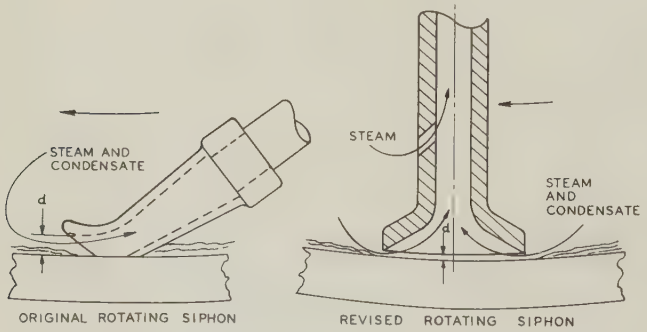
through rate, leading to large external piping pressure drops, and thus increasing still further the over-all pressure difference needed to maintain condensate removal. In order to conserve this large amount of blow-through steam, driers have been commonly grouped in cascade, i.e., the blow-through steam from one group is used to feed a next group operating at lower pressure. The grouping of driers in this way is in itself a problem because of the great variation in blow-through rate with condensing rate and other factors. Thus, at high condensing rates, the number of driers using blow-through steam from a preceding section may be very small, but with lower condensing rates, the ratio of driers in two successive groups must be closer to one.

The above factors lead to considerable difficulty in arranging and operating drier sections with rotating siphons at high speeds. This difficulty is further aggravated by the fact that for light sheets such as newsprint, the maximum steam pressure in any of the driers is preferably quite low. Therefore, the available pressure difference for evacuation of condensate and blow-through for two or three sections in cascade is sometimes available only by maintaining an appreciable vacuum on the condensate receiver from the lowest pressure drier section. This is expensive and sometimes difficult.

Because of these drier drainage system operating complexities associated with rotating siphons, it was realized that quantitative flow and pressure drop siphon behavior data were needed for high-speed, rimming drier operating conditions, and that an improvement in design was desirable. To obtain these data, the following experiment was conducted. These data and their correlation are the main theme of this paper. A new rotating siphon design was worked out which eliminated some of the high-speed difficulties encountered with the original rotating siphon. Also, a new stationary siphon, suitable for high-speed rimming driers was developed. This stationary siphon design constitutes a radical departure from the old style simple stationary siphon mentioned above. These designs and their flow and pressure drop characteristics are also reported on here.

DESCRIPTION OF THE EXPERIMENT

The experimental setup with which this study was made is shown schematically in Fig. 4. The drier was an actual 5 ft. diam. paper drier with a 60 in. face width. It was motor driven with a speed control allowing any surface speed from zero to 3000 f.p.m. to be maintained. The drier was fed from a steam



Patented and patent applied for.

Fig. 3. Original and revised rotating siphon inlet designs

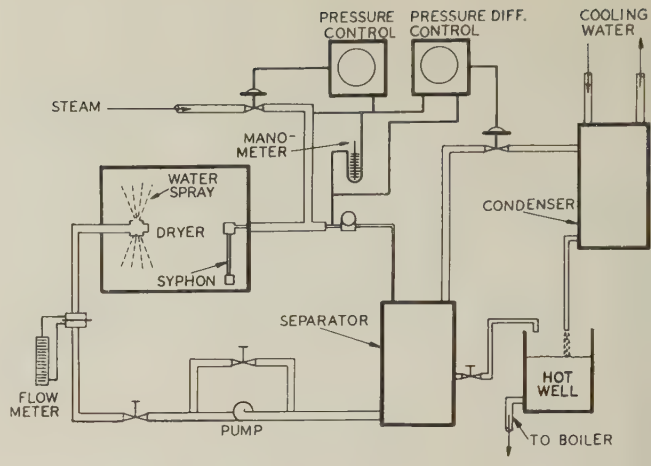


Fig. 4. Drier drainage experiment schematic

supply line in which a pressure of about 120 p.s.i.g. was maintained. Steam pressure to the drier and pressure difference between the steam inlet and the condensate outlet were maintained by means of conventional type pressure regulators and air control valves. The actual pressure differences between the steam inlet to the drier and the condensate outlet pipe was measured with a mercury manometer. The actual amount of steam condensed in the system was small so that the pressure at the steam inlet and that inside the drier were very close to equal. The pressure tap on the condensate outlet was installed at a point where the velocity of the blow-through steam was small. Thus, the measured pressure difference was essentially the total pressure drop associated with the flow of condensate and blow-through steam through the radial and axial siphon piping, not depreciated by any recoverable velocity head at the exit, nor including any external piping losses.

In order to simulate condensing rates of controllable and large enough magnitude, hot water from the condensate separating tank was pumped back into the drier through the front journal and through several spray nozzles inside the drier. The quantity of condensate flowing into the drier was controlled by the valve in the by-pass line around the pump, and was measured by a calibrated orifice and manometer. This condensate flow rate was then corrected to account for the steam actually condensed in the system due to heat losses by adding to it the rate of flow of water directly from the separating tank, through a small heat exchanger not shown, to the hot well. The separating tank was maintained at a constant level by means of a float control. The pump capacity allowed a maximum rate of condensate flow into the drier of about 2500 lb. per hr.

The blow-through steam from the separating tank was throttled through the air operated pressure difference control valve and then condensed in a heat exchanger. The blow-through rate was determined by measuring the rate of flow of condensate from the heat exchanger. The separating tank and all piping was insulated, and the external piping pressure drop was small so that it was not found necessary to apply any correction to the blow-through as measured in this way.

The test procedure consisted of setting the drier speed, steam pressure, condensate flow rate into the

drier, and the pressure difference at selected values. The drier was then allowed to run at a fixed condition for about half an hour in order to reach an equilibrium temperature and condensate level in the drier and in the separating tank. Then two or three successive measurements of blow-through rate were made, and the pressures at various points and temperatures indicated by thermocouples at various points in the system were read so that a check on possible heat losses could be made. For each speed, steam pressure, and condensate flow rate, the pressure difference was reduced by steps until a "flooding" condition was reached; that is, the point where the condensate was not removed as fast as it was introduced. At this condition, the condensate layer in the drier gradually rose until the siphon inlet became submerged. With the original model rotating siphon, all flow from the condensate pipe stopped at this point, as observed by means of a sight glass in that line. After allowing the rimming condensate layer to build up for a few minutes, the pressure difference was set high enough to start and maintain condensate flow, and the required pressure difference was recorded.

The amount of residual water in the drier after any run was determined by simultaneously shutting off the condensate return pump, reducing the pressure difference to zero, and stopping the drier rotation with the siphon pipe down. Then the water in the drier was all pumped into the separating tank by reapplying a small pressure difference. The valve in the separating tank level control line was shut off so that the amount of water removed from the drier could be measured by means of a sight glass on the tank.

In the low speed, nonrimming tests, drive power associated with the nonrimming condensate puddle agitation was measured by means of an ammeter and voltmeter on the drive motor.

A series of tests was also run with one of the drier heads removed so that the behavior of the condensate in the drier could be observed directly. These tests were run with cold water and the drainage pressure difference was obtained by connecting a vacuum pump to the separating tank. In this case, the blow-through was air. These test results are not included here. All of the data presented here were obtained with actual steam in the drier.

STATIONARY SIPHON

The stationary siphon being discussed here is *not to be confused with the type of simple stationary siphon referred to earlier.* The performance data presented were obtained as part of a development program which resulted in a new design stationary siphon capable of evacuating condensate from a thin rimming layer in high-speed operation as well as from a condensate puddle in a low-speed drier. This new design involves radical changes in the elements to permit accurate spacing between the siphon inlet tip and the drier bore. The siphon tip was also redesigned.

Turning now to the quantitative consideration of the pressure differences associated with the stationary siphon operation, we first consider the flow friction pressure drop occurring when condensate and blow-through steam is removed through the siphon piping. This is a case of two-phase flow pressure drop through stationary piping. The flow is turbulent throughout the range of interest. This problem has been extensively investigated by Lockhart and Martinelli (*2*). Their correlation for turbulent two-phase flow pressure drop through smooth horizontal pipes gives a single curve for the quantity $\sqrt{\Delta P_{TP}/\Delta P_P}$ plotted against a parameter X which is defined as

$$X = \sqrt{\frac{\Delta P_L}{\Delta P_G}} \qquad (1)$$

ΔP_{TP} is the two-phase pressure drop. ΔP_L and ΔP_G are the pressure drops which would occur if the liquid phase only and the gas phase only, respectively, were flowing through the same pipe and at the given rates. These single-phase pressure drops may be computed from well-known pressure drop formulas, or may be easily measured. Lockhart and Martinelli also obtained a single curve for the fraction, R_L, of the volume of the pipe occupied by the liquid during the two-phase flow as a function of X. These curves for two-phase pressure drop and for R_L approximately fit the equations

$$\Delta P_{TP} = \Delta P_L \left(1 + \frac{21}{X} + \frac{1}{X^2}\right) \qquad (2)$$

and

$$\left(\frac{1}{R_L}\right)^2 = 1 + \frac{21}{X} + \frac{1}{X^2} \qquad (3)$$

NOMENCLATURE

C	= ratio of centrifugal acceleration to that of gravity
g	= acceleration of gravity, feet per second squared
h	= thickness of rimming condensate layer, feet
h_o	= condensate layer thickness near siphon inlet or at the edge of a condensate groove, feet
$h_{max.}$	= maximum thickness of the condensate layer, feet
$h_{av.}$	= average thickness of the condensate layer, feet
k	= constant
l	= perimeter of the spot on the inside of the drier shell within which the condensate is being entrained by blow-through steam, or the length of one edge of a condensate groove, feet
L	= face width of drier shell, feet
m	= constant
p	= pressure
Q	= rate of flow of condensate over the drier shell inside surface per unit length normal to the flow, square feet per second
R_L	= the fraction of the volume of the radial siphon pipe which is occupied by the liquid phase
R_i, R_o	= inside and outside radius of the drier shell, respectively, feet
r	= distance over the inside surface of the drier shell from the siphon inlet to any point on the shell surface, feet
S	= drier surface speed, feet per minute
u	= velocity of condensate relative to the drier shell, feet per second
V	= velocity, feet per second
v	= specific volume of condensate or steam, cubic feet per pound
W	= rate of flow of condensate or steam, pounds per hour
X, Y	= pressure drop ratios used as parameters in two-phase flow correlations
x	= distance from the edge of a condensate groove in the drier shell to any point on shell surface, measured along the shell axis, feet
y	= distance from inside surface of drier shell to any point in the condensate layer, measured normal to the shell surface, feet
μ	= viscosity of the condensate, pounds per foot second

Subscripts

$_{TP}$ pertains to two-phase flow
$_L$ pertains to the liquid phase
$_G$ pertains to the gas phase (i.e. steam)
$_C$ denotes centrifugal pressure drop

In the Appendix, some additional subscripts are used with the above nomenclature. The terms so used are defined where given.

Our stationary siphon differs from the smooth horizontal pipes for which the above equations apply in several respects. Although the piping involved is commercially smooth, the flow path through the siphon involves one entrance, at the siphon inlet tip, two pipe bends of fairly large radius and with no abrupt changes in cross section, and a smooth exit from the axial siphon pipe into an enlarged space. It was found that for our stationary siphon, the single-phase pressure drop for either water or steam only is given by

$$\Delta P = 2.4 \times 10^{-6} v W^2 \quad \text{p.s.i.} \qquad (4)$$

while for smooth pipes, the pressure drop would be a function of viscosity and would vary as the 1.75 or 1.8 power of flow rate, W.

In spite of these differences, we would still expect that the general form of equations (1), (2), and (3) would be applicable to our system, but that the empirical constant, 21, might be different. However, the stationary siphon was not tested extensively for flow pressure drop data since the major problem in its development was mechanical. The exact flow pressure drop characteristics of a stationary siphon are not too important in regard to specifying operating conditions because the pressure difference needed is always small, and the blow-through steam rate is moderate. In addition, our measurements, particularly of condensate flow rate, were not of sufficient precision to determine exactly the best value of the empirical constant in equation (2). Therefore, equations (1), (2), and (3) were applied directly in an attempt to correlate our stationary siphon data.

In addition to the two-phase flow friction pressure drop, there will be a pressure drop associated with the liquid part of the flow being lifted against gravity through the radial (vertical) siphon pipe. This height is 2.4 ft. in our case. Also, we must take into account the effect of the velocity head possessed by the condensate, moving with the drier with a velocity, V, with respect to the stationary siphon inlet. This velocity head may be considered as being possessed by a mixture of density R_L/v_L. Therefore, the pressure exerted by the mixture entering the pipe will be

$$\frac{R_L V^2}{2g v_L}$$

This pressure constitutes a driving force which, in addition to the steam pressure difference across the siphon, is available to maintain flow of steam and condensate through the system. Therefore, it is to be subtracted from the total steam pressure difference needed for a given condition.

Expressing all of the pressure drop terms in p.s.i. units and in terms of the surface speed of the drier, S, in feet per minute for our drier which has an inside radius of 2.4 ft., and an outside radius of 2.5 ft., the total pressure drop through the stationary siphon, based on the above considerations would be

$$\Delta P = \Delta P_L \left(1 + \frac{21}{X} + \frac{1}{X^2}\right) - \frac{R_L}{144 v_L} (3.96 \times 10^{-6} S^2 - 2.4) \quad \text{p.s.i.} \qquad (5)$$

Equations (1) through (5) may be used to calculate the blow-through versus pressure drop curve for our stationary siphon for any operating condition. Two such calculated curves are shown in Fig. 5 together

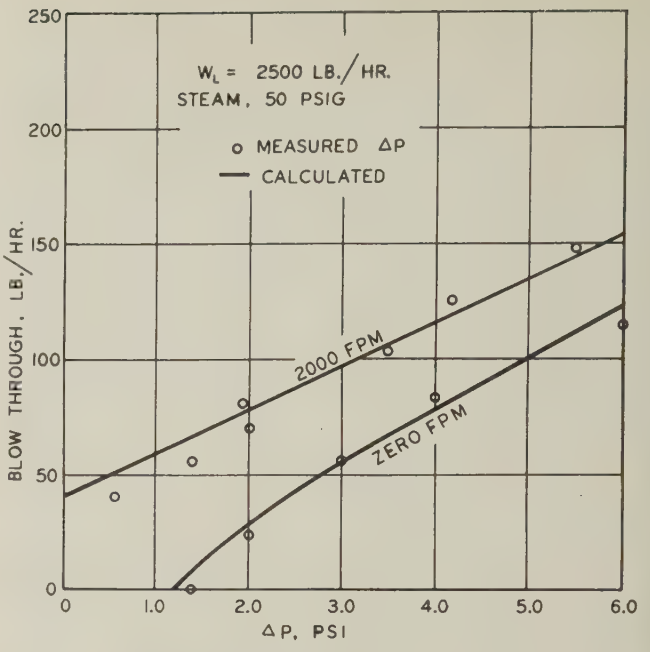


Fig. 5. Stationary siphon, blow through versus pressure difference at high and low speeds

with data measured in the experiment for the same conditions. The agreement between the measured and calculated values indicates that equation (5) can be used to approximately describe the stationary siphon behavior with sufficient accuracy for purposes of specifying operating conditions and for the sizing of drainage systems.

In Fig. 6 are shown several calculated curves of blow-through versus pressure difference for various condensing rates at lower speeds where there is no appreciable self pumping.

As shown in Figs. 5 and 6, the pressure difference needed with the stationary siphon to assure drainage is always very low, even if reasonable blow-through rates are maintained. There is never any centrifugal force to be overcome as in the rotating siphon. Pressure difference control of a drier drainage system with these stationary siphons is not difficult due to the fact that the variation of blow-through with pressure difference is moderate. The minimum residual water obtainable with the stationary siphon depends mainly on the clearance between the siphon tip and the drier shell. This clearance can be made as small as desired at assembly, with the new stationary siphon. The minimum condensate layer thickness possible in the case of a rimming drier is discussed in the Appendix.

ROTATING SIPHON

Most of the drier drainage experimentation was done with a rotating siphon which was the Beloit Iron Works standard model at the time the work was started. This is referred to in this paper as the original model rotating siphon to distinguish it from the revised rotating siphon to be discussed later. The original rotating siphon had a curved rotating siphon pipe with an internal diameter of 1.05 in. It was fitted with a condensate inlet shoe as illustrated schematically by Figs. 2 and 3.

Consideration of the pressure difference associated with operation of the rotating siphon must include the

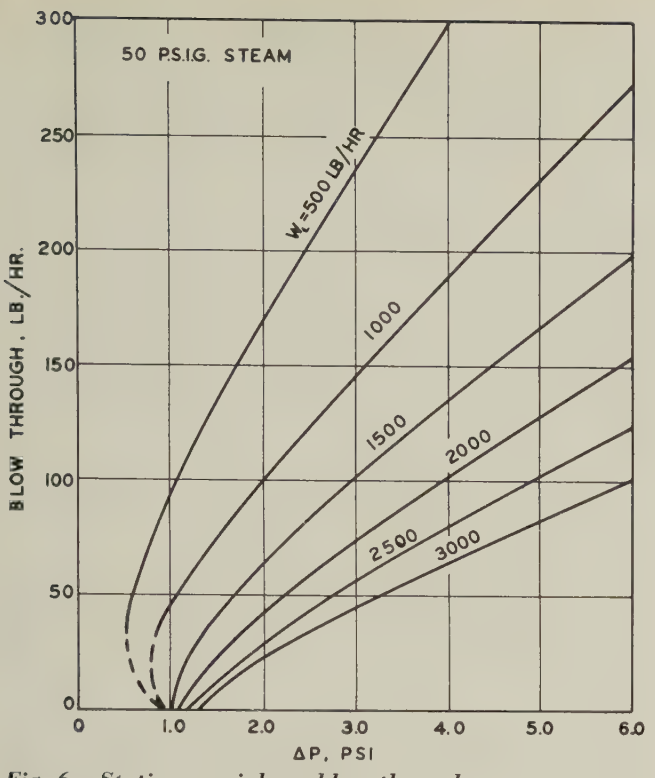


Fig. 6. Stationary siphon, blow through versus pressure difference at low speed with various condensing rates

effect of centrifugal force, which may easily be shown to be*

$$\Delta P_C = 2.68 \times 10^{-8} \frac{S^2}{v_L} R_L \qquad \text{p.s.i.} \qquad (6)$$

if the liquid volume fraction, R_L, is constant over the length of the radial siphon pipe.

For the two-phase flow friction pressure drop through the rotating siphon piping, we may again use the formulas of the same form as those which were successfully applied to the stationary siphon. From single-phase pressure drop tests with the original model rotating siphon, we found that for the flow of either water or steam only,

$$\Delta P = 1.52 \times 10^{-6} v W^2 \qquad \text{p.s.i.} \qquad (7)$$

Two-phase pressure drop tests made with the drier not rotating gave the results shown in Fig. 7. These results, for the original model rotating siphon, may be approximately expressed by the equation

$$\Delta P = \Delta P_L \left(1 + \frac{9.3}{X} + \frac{1}{X^2}\right) \qquad (8)$$

Therefore, it appears that the general form of equation (2), for smooth horizontal pipes, is still applicable to our rotating siphon except that the empirical constant, 21, is changed, as was already anticipated in the discussion of the stationary siphon. This change in constant was more definitely pointed out by the rotating siphon data than by the stationary siphon data. A larger amount of data was obtained for the rotating siphon. Also, the rotating siphon differed from a smooth pipe more than did the stationary siphon. There were abrupt changes in cross section between the radial and axial pipes and at the axial pipe outlet.

It is reasonable to expect that the relationship between R_L and the ratio of two-phase pressure drop to the liquid phase pressure drop is more fundamental than the exact form expressed by equation (3). Therefore, we assume that R_L may be expressed by

$$\left(\frac{1}{R_L}\right)^2 = 1 + \frac{9.3}{X} + \frac{1}{X^2} \qquad (9)$$

If the liquid volume fraction, R_L, in the rotating siphon pipe is not appreciably affected by the centrifugal force, the total pressure drop for the rotating siphon is given by

$$\Delta P = \Delta P_L \left(1 + \frac{9.3}{X} + \frac{1}{X^2}\right) + 2.68 \times 10^{-8} \frac{S^2}{v_L} R_L \qquad \text{p.s.i.} \qquad (10)$$

Equation (10) does not include any gravity term, since the time average effect of gravity is zero, and no cyclic effect of importance was observed. The equation applies, of course, only to the condition of steady state flow (i.e., when the drier is rimming) which is being considered in this paper.

Equations (1), (7), (9), and (10) may then be used to calculate the pressure drop for the original rotating siphon for any set of specified conditions in the rimming condensate range or may be used to construct blow-through versus pressure drop curves for any given speeds, condensing rates and steam pressures. A comparison of calculated and measured pressure drop values for a wide range of conditions is shown by Fig. 8, and a comparison of typical measured and calculated blow-through versus pressure drop curves is shown in Fig. 9. The formulas give the pressure drop within $\pm 20\%$. Figure 8 shows only as much data as could be put on one graph without excessive overlapping of points. Calculations and measurements were actually made for 137 points, and all of the data lie within the $\pm 20\%$ band.

Using the above equations, a set of curves showing the variation of pressure drop versus blow-through steam for a set of evenly spaced increments of steam pressure, condensing rate and speed was calculated. Due to the large number of combinations of conditions needed to properly define the curves over the range of interest, these calculations as well as those involved in correlating the measured data were made on an IBM 650 computer.

A few of these curves are shown in Fig. 10, which shows the trend of blow-through versus pressure drop

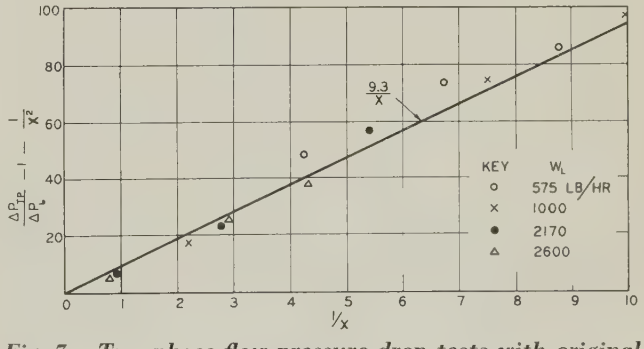


Fig. 7. Two-phase flow pressure drop tests with original rotating siphon at zero speed

* Although the rotating siphon pipe in the original model was curved, this curvature has no effect on the centrifugal force pressure drop. Additional dynamic forces do act on a particle flowing through the rotating curved pipe. However, they are in a direction normal to the pipe wall and do not add or subtract from the pressure drop.

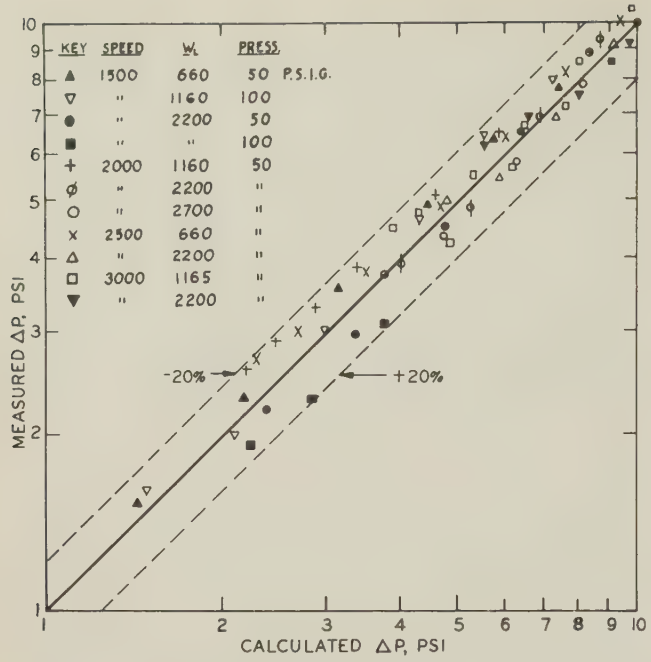


Fig. 8. Correlation of rotating siphon pressure drop data with calculated pressure drop

curve variation with condensing rate, and in Fig. 11, which shows the effect on these curves of speed. The pressure drop always reaches a minimum value at some small blow-through rate. At higher blow-through rates, the pressure drop due to flow friction increases. At lower blow-through rates, the centrifugal force pressure drop predominates. At zero blow-through rate, the pressure difference needed to maintain condensate flow is equal to the centrifugal force pressure drop for the radial pipe filled with water. This is a very possible condition that exists whenever the siphon pipe inlet becomes submerged in the condensate layer, which may result from a temporary loss of pressure difference across the steam fit. At higher speeds, this pressure drop becomes very large. If this large pressure difference is regarded as the required operating pressure differential in order to assure condensate removal under all conditions, then under normal operating conditions where the siphon inlet is not submerged, the equilibrium flow condition is one with a very large blow-through rate.

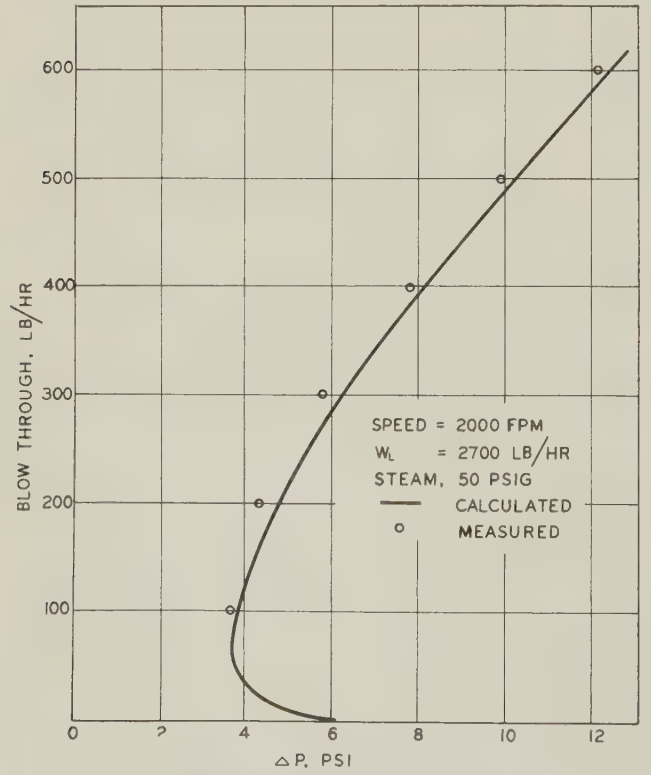


Fig. 9. Rotating siphon blow through versus pressure difference

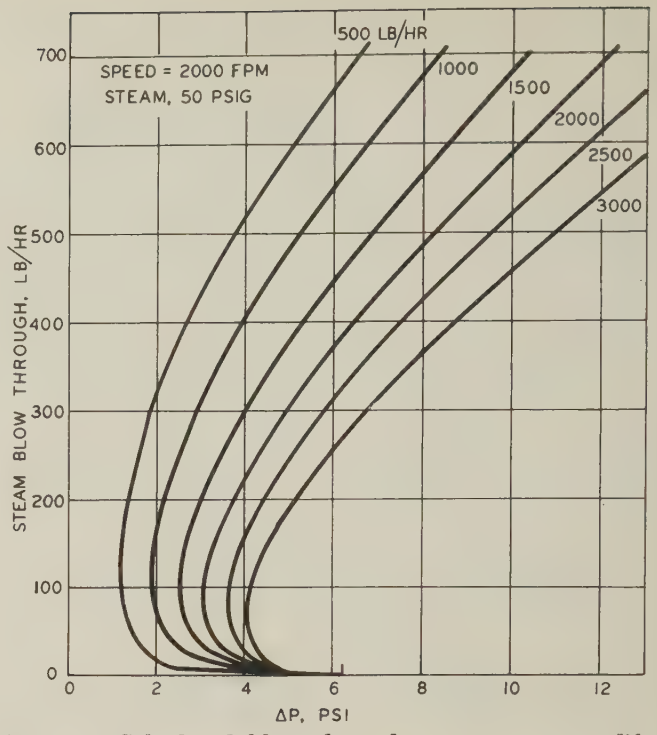


Fig. 10. Calculated blow through versus pressure difference for various condensing rates for the original model rotating siphon

Even if a pressure difference near the minimum

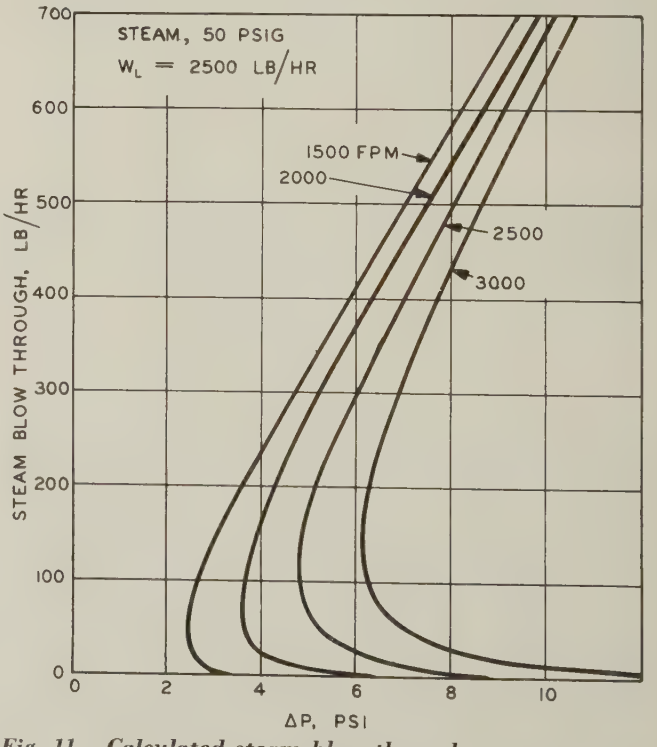


Fig. 11. Calculated steam blow through versus pressure difference for various speeds for the original model rotating siphon

value is regarded as a safe operating pressure difference, the ordinary rotating siphon gives some drainage system sizing and control difficulties due to the fact that the blow-through rate varies appreciably with pressure difference and with condensing rate.

REVISED ROTATING SIPHON*

In order to overcome some of the difficulties inherent with the ordinary rotating siphon, a new rotating siphon was developed as an outgrowth of this drier drainage study. In addition to the operating difficulties discussed above, the original rotating siphon requires an excessive amount of blow through steam to maintain a minimum residual water layer thickness in a rimming drier. As discussed in the Appendix, to maintain the minimum residual condensate layer thickness for a given condensing rate, a certain steam velocity entering the siphon inlet is needed. This velocity can be obtained with considerably less blow-through steam if the height of the siphon inlet above the drier shell is reduced. This comparison is shown in Fig. 3, where the original and revised rotating siphon inlets are illustrated schematically. The new siphon inlet was also made round so that condensate could approach the syphon inlet from all directions, thus increasing the perimeter, l, referred to in the formulas for estimating the residual water layer thickness given in the Appendix.

With the dimension, d, in Fig. 3 reduced to a very small value, the likelihood of the siphon inlet becoming submerged was even greater than with the original rotating siphon. Therefore, a steam bleed hole was provided close to the bottom of the siphon inlet, as shown in Fig. 3. Even though the condensate inlet at the bottom of the siphon tip becomes temporarily submerged, enough steam can enter the bleed hole to keep the liquid volume fraction, R_L, and the centrifugal force pressure drop close to the values prevailing at the minimum total pressure drop condition. The bleed hole is high enough above the drier shell to remove the possibility of its ever becoming covered with a rimming condensate layer, and yet close enough to the siphon inlet to serve its purpose.

Residual water measurements made with the revised siphon showed that for pressure differences near the safe value needed for evacuation, the condensate layer thickness was usually close to the minimum value as estimated in the Appendix. This was usually less than half as much condensate as that maintained by the original rotating siphon operating at the same pressure difference and with a larger blow-through rate.

* Patent applied for.

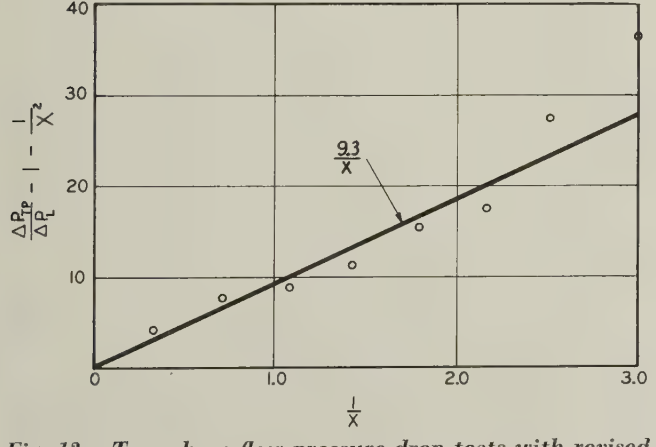


Fig. 12. Two-phase flow pressure drop tests with revised rotating siphon at zero speed

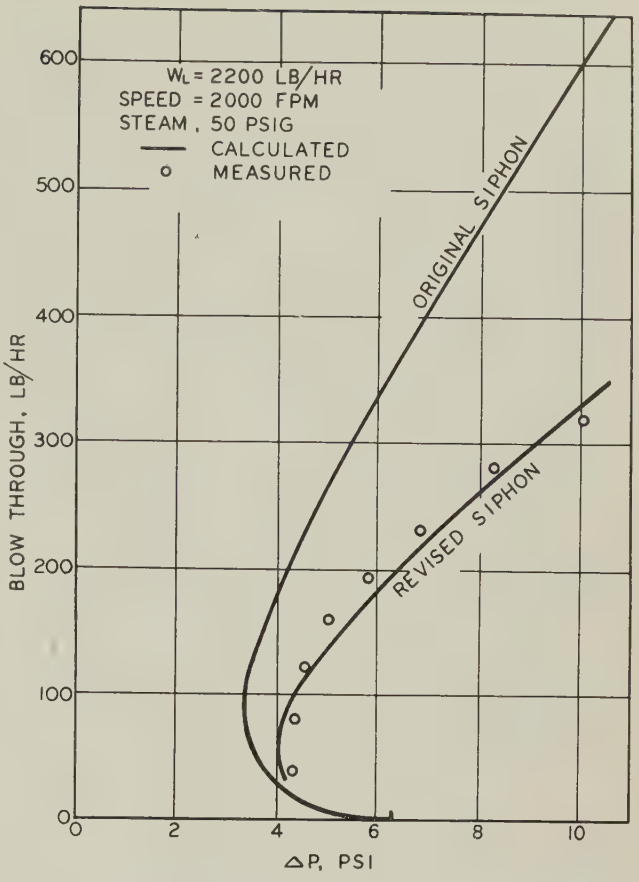


Fig. 13. Blow through steam versus pressure difference for revised rotating siphon and original model rotating siphon

Turning now to the correlation of pressure drop data for the revised siphon, we may again expect to use formulas of the same form as those used for the original model rotating siphon. In order to determine the the possible effect of changing the radial pipe size and shape on the constant in equation (8), two-phase flow pressure drop tests were again made for the new siphon with the drier not rotating. These results are shown in Fig. 12. Although we might expect that the constant in equation (8) would be slightly different with the new rotating siphon, our data were not of sufficient quantity or precision to definitely indicate what this change should be. Therefore, the same constant, 9.3, was taken as being approximately correct. This is in fair agreement with the data shown in Fig. 12.

With the reduced size radial siphon pipe and with the revised inlet, the single-phase pressure drop through the new rotating siphon was found to be

$$\Delta P = 2.9 \times 10^{-6} v W^2 \quad \text{p.s.i.} \qquad (11)$$

A complete set of blow-through versus pressure drop curves was calculated for the revised siphon, using equations (1), (9), (10), and (11). A comparison between the calculated and measured data is shown for one set of conditions in Fig. 13.

Figure 13 also shows the comparison between the

blow-through versus pressure drop curves for the revised and the original rotating siphons. The blow-through is greatly reduced at the higher pressure differences. However, the minimum pressure difference is not increased in nearly the same proportion. This is due to the fact that at the minimum pressure drop condition, a large part of the pressure difference is due to centrifugal force, and this is not increased in the new design siphon.

For the set of conditions specified in Fig. 13, the required operating pressure difference for the revised siphon would be about 5 p.s.i. This includes a margin of error for the calculated minimum pressure difference and an additional pressure difference of about 0.3 p.s.i. needed to overcome the additional centrifugal force acting on the water between the condensate inlet and the bleed hole in the event that the condensate inlet becomes submerged. With this pressure difference, the blow-through rate would be only about 150 lb. per hr. The safe pressure difference for the original rotating siphon would be about 6.4 p.s.i. for which the blow-through rate would be almost 400 lb. per hr.

Under all conditions the revised rotating siphon can be operated safely with less pressure difference than that required with the original rotating siphon. Either with or without a condensate groove in the drier shell, the residual condensate layer will be smaller with the revised rotating siphon unless extremely large blow-through rates are maintained in the original rotating syphon. With the revised rotating siphon, the blow-through rates are smaller for any given values of pressure drop, and blow-through changes less with condensing rate, speed, and pressure difference. Therefore, the control of a drainage system is simplified.

Compared with the stationary siphon, the revised rotating syphon does require moderately greater pressure differences at the higher speeds, however, it is mechanically simpler.

The correlation fomulas for the rotating siphons are seen to give suitably accurate expressions for operating pressure differences. Therefore, the formulas themselves, or at least the form of the equations should be of value for other siphon design improvement studies. Also, they allow for the application of the test data to conditions other than those actually existing in any of the test runs. This is important because it would have required about six times as much data as were actually accumulated in the experiment in order to properly define the original rotating siphon performance over the whole range of interest, and these same amounts of data would have to be accumulated again for the revised siphon.

It is expected that certain refinements in the formulas are in order, some of which are discussed in the Appendix. These would be of academic interest in explaining the flow phenomena as well as in improving the accuracy of the formulas. As discussed in the Appendix, these refinements could not be verified by our data. However, our purposes are sufficiently well served by the simplified formulas given.

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APPENDIX

Refinements in the Study of Pressure Drop Through Siphons

If we regard blow-through rate as an independent variable in our experiments, then the only dependent variable which was measured in our flow versus pressure drop studies was the total ΔP for the siphon system. This total pressure drop is made up of several components and is affected by many factors. Although the relatively simple correlation formulas given serve our practical purposes fairly well, it would be desirable, both to obtain more accurate formulas and to arrive at a better understanding of the flow versus pressure drop phenomenon, to analyze the pressure drop in terms of a more complete break-down of these various components. Two-phase pressure drop is not amenable to purely analytical treatment. Therefore, it was not possible, with our limited data, to make such a break-down. In any further study of the flow and pressure drop in siphons, separate measurements should be made of entrance and exit pressure drops, the pressure drop in the rotating pipe, and the pressure drop in the horizontal axial siphon pipe. Also, the liquid volume fraction should be directly measured for various parts of the system. Then each of the separate pressure drops and also the liquid volume fraction could be correlated with the flow parameters individually, and using a form most suitable to each component.

For the two-phase pressure drops at entrances and exits and for flow around bends, it is very likely that an equation of the same form as equation (2) will hold, except that the empirical constant will probably be much smaller.

For flow through the relatively smooth horizontal siphon pipe, Lockhart and Martinelli's results should apply directly. The single-phase pressure drops would probably vary as a smaller power of flow rate than was found for our total system pressure drop values.

For the pressure drop through the radial siphon pipe, the effect of centrifugal force on the liquid volume fraction should be taken into account. It is to be expected that this quantity will be increased somewhat by centrifugal force. This will have two opposite effects on the pressure drop through the rotating radial pipe. The centrifugal force pressure drop itself will, of course, be greater than predicted by our formulas. However, it may be expected that the flow friction pressure drop will be smaller as a result of decreased condensate velocity resulting from an increase in R_L. These effects would both be reflected by an equation of the form

$$\Delta P = \Delta P_L \left(\frac{1}{R_L}\right)^m + R_L \Delta P_C \qquad (12)$$

where ΔP_C is the centrifugal force pressure drop for a siphon pipe full of water. As suggested by the work of Chisholm and Laird (*3*), the exponent m would probably have the same value as the exponent of flow

rate in the single-phase pressure drop formulas, which for the relatively smooth siphon pipe would be about 1.75 or 1.8.

A suggested form for the liquid volume fraction correlation would be

$$\left(\frac{1}{R_L}\right)^m = 1 + \frac{k}{Y} + \frac{1}{Y^2} \qquad (13)$$

where Y is given by

$$Y = \sqrt{\frac{\Delta P_L + \Delta P_C R_L{}^{m+1}}{\Delta P_G}} \qquad (14)$$

This form is suggested by equation (12) factored to give

$$\Delta P = \left(\frac{1}{R_L}\right)^m (\Delta P_L + \Delta P_C R_L{}^{m+1}) \qquad (15)$$

from which the term in the brackets is used in the calculation of the quantity Y in the same way that ΔP_L is used for the calculation of X for a nonrotating system.

Another factor which should be considered in the analysis of the siphon system is the effect of possible phase changes with change in pressure along the siphon piping. In addition to the possibility of flashing of condensate, there may be some condensing of steam near the beginning of the siphon pipe flow path because of the fact that the condensate layer in a rimming drier may be substantially subcooled.

This phase change was ignored in the preceding discussion. This does not enter into the direct applicability of our data, since the blow-through rate was measured as the flow rate of steam leaving the drier, which is the quantity of interest in application. Also, the neglect of phase changes does not alter the validity of the conclusion that the full centrifugal force pressure drop, ΔP_C, is needed to maintain flow from a flooded drier in the case of the original model rotating siphon. When the drier is flooded, the condensate layer will be very much subcooled. Therefore, it will not flash into steam and will not reduce the density of the fluid in the radial siphon pipe. This was confirmed by our experiments. It is expected that the phase change through the siphon pipe is small under most conditions. The enthalpy available, with reasonable pressure drop values, is not great. Also, the time spent in the siphon piping by any particle of liquid is very short so that the mixture may not be in complete equilibrium. However, a more thorough study of the mechanisms involved in the siphon flow and pressure drop process should certainly include a measurement of the phase changes, or rather of the liquid volume fraction as affected by phase changes.

Estimating the Minimum Thickness of the Residual Condensate Layer in a Rimming Drier

The flow of condensate over the drier shell surface when the condensate is rimming may be treated as a problem of flow over a flat plate with the modification that the pressure gradients due to variation in the height of the liquid layer are multiplied by the ratio of the centrifugal acceleration to the acceleration of gravity. This ratio, C, for our 5-ft. diam. drier is

$$C = 33.2 \times 10^{-6} S^2 \qquad (24)$$

With a rotating siphon in a drier without a condensate groove, the thickness of the condensate layer immediately under the syphon inlet will depend on the amount of blow-through steam entering the siphon pipe, and more specifically will depend on the velocity of the blow-through steam at this point. For a sufficiently high steam velocity, the area under the siphon inlet will be swept completely clean of condensate, and no further increase in blow-through will result in any reduction in residual water in the drier. This behavior has been observed in our experiments. Under these conditions, the quantity of residual water in the drier is determined entirely by the rate at which condensate is being formed, and by the factors affecting flow of the condensate over the shell surface.

If the drier shell has a condensate groove at one end in which the siphon is maintaining a level of condensate at most not any higher than the groove depth, or in the case of the stationary siphon with close enough clearance to sweep a ring around the drier essentially free of condensate, the residual water layer thickness will again be at a minimum as far as the possible influence of the siphon is concerned.

In both cases, the height of the water layer at the edge of the spot or groove may be estimated by using the Francis formula for a flat crested dam (*4*), modified for the effect of centrifugal force on the pressure head, to give

$$h_o = \left(\frac{W_L v_L}{449 l}\right)^{2/3} \left(\frac{1}{C}\right)^{2/3} \text{ ft.} \qquad (16)$$

where l is the perimeter of the spot or the length of one edge of the groove in feet.

Over the main surface of the drier, we have a condition of laminar flow of condensate in which the pressure gradient along the flow direction is

$$\frac{\partial p}{\partial x} = \frac{C}{v_L}\frac{\partial h}{\partial x} = \frac{\mu}{g}\frac{\partial^2 u}{\partial y^2} \qquad (17)$$

A solution for the distribution of the velocity, u, over the distance, y, above the drier shell is given by

$$u = 3Q\left(\frac{y^2}{2h^3} - \frac{y}{h^2}\right) \qquad (18)$$

Substituting this in equation (17) gives

$$h^3 \frac{\partial h}{\partial x} = \frac{3\mu v_L}{gC} Q \qquad (19)$$

When the condensate is flowing to a groove, and assuming a uniform rate of deposition of condensate over the drier shell inside surface,

$$Q = \frac{W_L v_L}{3600 \times 2\pi R_i}\left(\frac{L - x}{L}\right) \qquad (20)$$

where L is the drier width and x is the distance along the drier width from the groove edge. Solution of equations (19) and (20) then gives the height of the condensate layer at the far end of the drier, the maximum height,

$$h_{\text{max.}}{}^4 = h_0{}^4 + \frac{3\mu v_L{}^2 W_L L}{\pi S^2}\left(\frac{R_o}{R_i}\right)^2 \text{ ft.} \qquad (21)$$

and the average height of the condensate layer

$$h_{\text{av.}} = \frac{4}{5}\left[\frac{h_{\text{max.}}{}^5 - h_0{}^5}{h_{\text{max.}}{}^4 - h_0{}^4}\right] \text{ ft.} \qquad (22)$$

When the condensate flows over the drier surface to a spot, we may roughly approximate the spot by a circle of radius r_o and the drier inside surface by a half-

circular area of radius r_l, where r_l is equal, very roughly to the maximum length of travel of the condensate over the shell surface which is the drier width, L. Then the condensate flow rate, Q, at any distance, r, from the siphon inlet, will be

$$Q = \frac{W_L v_L}{3600\pi r}\left(\frac{r_l^2 - r^2}{r^2}\right) \qquad (23)$$

The corresponding formula for $h_{max.}$ is

$$h_{max.}^3 = h_0^3 + \frac{3\mu v_L^2 W_L R_o^2}{R_i \pi S^2}\left[\ln \frac{r_l}{r_o} - \frac{1}{2}\left(1 - \frac{r_o^2}{r_i^2}\right)\right] \quad \text{ft.} \qquad (33)$$

In this case the increase in layer height across the drier is very small compared with the height at the siphon tip edge, and it increases form h_o to $h_{max.}$ in a short distance from the siphon inlet. Therefore the average layer thickness will be very close to the maximum thickness.

As an example, these formulas yield the following results when the drier is 16 ft. wide, rotating at a speed of 2000 f.p.m. with a condensing rate of 2000 lb. per hr., and with a steam pressure of 50 p.s.i.g. for which v_L is 0.01743 cu. ft. per lb. For the case of no condensate groove, the spot was assumed to be a $2^3/_4$ in. diam. circle, the diameter of the siphon inlet of the revised rotating siphon.

	No groove, in.	*With groove, in.*
h_o	0.099	0.0138
$h_{max.}$	0.100	0.0545
$h_{av.}$	0.101	0.0438

These results are in fair agreement with the average water layer thickness for comparable cases as measured in our experiments. The actual effect of a condensate layer as thermal insulation is not so serious as would be concluded by regarding the condensate as a stagnant insulating layer having the conductivity of water. Apparently there is some forced convection in the condensate in a rotating drier. Not much is known about the heat transfer coefficients between the steam and the drier shell with rimming condensate, and this question warrants study.

The Effect of Chlorinating and Oxidizing Agents on Derivatives of Oleic Acid

BENGT LEOPOLD and DONALD B. MUTTON

The effect of a number of chlorinating and oxidizing agents on oleic acid and triolein has been studied. The chemical changes occurring in the fatty materials were determined, and the effect of these changes on the saponification behavior and the physical properties of triolein were investigated. With aqueous chlorine, almost complete saturation of the triolein occurs, the main reactions being the addition of chlorine and hypochlorous acid to the double bond. The highly chlorinated triolein is very hydrophobic and strongly resistant to aqueous saponification. At room temperature under the conditions used, from 25 to 50% of the double bonds in triolein were modified by chlorine dioxide. The reaction is accelerated by light and is probably free radical in nature. The most likely reaction path appears to be an oxidative cleavage at the double bond with the formation of aldehyde groups. This is accompanied by the formation of an equivalent amount of chlorine which then adds to another double bond. Triolein modified in this way is relatively easily saponified by aqueous alkali. Treatment with dilute sodium hypochlorite at 65°C. affected about 25% of the double bonds in triolein. The reaction is rather complicated and involves the introduction of carbonyl, carboxyl, epoxide and hydroxyl groups, as well as some chlorination. The least chemical change was brought about by alkaline peroxide at 65°C., the main reactions being the introduction of epoxide and hydroxyl groups. Both the hypochlorite and peroxide treated trioleins are more susceptible to aqueous saponification than triolein, although less reactive than the chlorine dioxide treated product. Some experiments were also carried out on the chlorination of oleic acid and methyl oleate in organic solvents. The reaction is complicated by a number of side reactions such as polymerization and addition of oleate ions and solvent anions to the double bonds. The results of this investigation are of interest in connection with problems of removing fatty extractives from hardwood pulps.

THE use of certain hardwood species for the manufacture of dissolving pulps is complicated by the fact that they may contain rather large amounts of extractives which are not easily removed during purification of the pulp. For example, pulp prepared from birch or poplar may contain up to 5% of material extractible with ether or alcohol:benzene. Analysis of these hardwood extractives shows that the major constituent is fat, present either as free fatty acids or neutral fat. Typical analyses of the extractives from unbleached sulphite pulp made from white birch are shown in Table I.

Most bleaching operations are designed primarily to remove lignin and hemicellulose from the pulp, and the effect that the various treatments have on the extractives is incidental. However, with hardwood pulps which contain large amounts of extractives, it is important to know how a given bleaching operation will affect both the removal of the extractives during subsequent operations and the properties of the extractives which will be left in the finished pulp.

For this reason, studies have been carried out in this laboratory on the reaction between the chlorinating and oxidizing reagents normally used in pulp bleaching and pure compounds representative of the materials found in hardwood extractives. The present paper is concerned with the effect of aqueous chlorine, chlorine dioxide, sodium hypochlorite, and hydrogen peroxide on

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Table I. Composition of Extractives from Unbleached Sulphite Pulp

	Unseasoned white birch	*Seasoned white birch*
Difficultly esterified acids, % ("resin acids")	2.5	7.0
Unsaponifiable, %	30.0	35.0
Free fatty acids, %	7.0	25.5
Esterified fatty acids, %	56.5	32.0
Recovery	96.0	99.5
Composition of fatty esters		
Saturated acids, %	1.5	
Oleic acid, %	49.5	
Linoleic acid, %	44.0	
Triene acids, %	5.0	

the chemical constitution and physical properties of the triglyceryl ester of oleic acid, triolein.

In addition, some experiments were carried out on the chlorination of oleic acid and methyl oleate in organic solvents. Analysis of the products revealed some interesting side reactions and these results are also included in this paper.

RESULTS

Analyses of the reaction products and the calculated composition of these materials are recorded in Tables II, III, and IV. In addition to the experimentally determined value (for example, per cent chlorine in the sample), the content of any particular functional group is expressed as equivalents per oleic acid unit. The most obvious reactive position in the oleic acid or ester molecule is the double bond, and it is likely that any addition or oxidation reactions will occur at that position. A complete analysis of the reaction product should, of course, be able to account for all the reactive positions represented by the original double bonds. Expressing the content of functional groups as equivalents per oleic acid unit makes such an accounting very much more convenient. Since each double bond represents two reactive positions, the sum of all the equivalents of groups introduced at the double bond should equal two.

Calculation of the content of any functional group as equivalents per oleic acid unit depends upon the formula weight of the oleic acid unit. For reasons which will be discussed in a later section of this paper, this formula weight is not always identical with the experimentally determined neutralization or saponification equivalent. Therefore a calculated formula weight, based on the increase in weight of the oleic acid unit caused by the functional groups introduced, is used to calculate the composition of the sample.

For a sample of chlorinated or oxidized oleic acid:

n = calculated formula weight of the oleic acid unit
n_x = neutralization equivalent
u = iodine number
c = per cent chlorine
h = per cent hydroxyl
k = per cent carbonyl oxygen
o = per cent oxygen
p = per cent peroxide oxygen
E_u = number of reactive positions at double bonds per oleic acid unit
E_c = equivalents chlorine per oleic acid unit, etc.

$$n = \frac{282}{1\text{-}0.01\ (c + h + k + o + p)}$$

Table II. Chlorination and Oxidation of Triolein—Analysis of Reaction Products

Expt. no.	*Reagent*	*Iodine number* u	*Chlorine, %* c	*Hydroxyl, %* h	*Carbonyl oxygen, %* k	*Epoxide oxygen, %* o	*Peroxide, %* p	*Saponification equivalent* s_x	*Free COOH, meq/g.* a	*Ester, meq/g.* e
...	Triolein	84.0	...	...	...	...	...	292	...	3.39
8	Cl_2	0.4	11.4	1.08	0.31	...	...	352	...	...
9	Cl_2	1.4	15.0	1.05	0.36	Nil	Nil	351	0.10	...
10	ClO_2 (gas)	38.1	5.04	0.80	2.25	...	Nil	259	0.40	2.87
11	ClO_2 (gas	59.5	2.72	0.60	1.61	0.28	0.32	267	Nil	3.35
12	ClO_2 (aq.)	63.8	1.83	0.90	0.92	0.10	0.01	280	0.59	2.82
13	NaOCl	61.9	2.22	1.05	1.49	0.12	1.07	285	0.50	2.90
14	H_2O_2	77.7	...	0.73	...	0.26	1.08	280	0.20	3.14
...	Methyl oleate	85.7	...	...	...	...	...	296	...	...
15	Cl_2	25.2	10.3	1.60	...	...	...	336	...	...

It can easily be shown that the following equations are applicable:

$$E_u = 0.788\ un \times 10^{-4}$$
$$E_c = 2.82\ cn \times 10^{-4}$$
$$E_h = 5.88\ hn \times 10^{-4}$$
$$E_k = 6.25\ kn \times 10^{-4}$$
$$E_o = 12.5\ on \times 10^{-4}$$
$$E_p = 3.12\ pn \times 10^{-4}$$

Table III. Chlorination and Oxidation of Triolein—Composition of Reaction Products

Expt. no.	*Reagent*	*Saponification equivalent calculated* s	*Saponification equivalent found* s_x	*Calculated content of functional groups in equivalents/equivalent of oleic acid*									
				Unsaturation E_u	*Chlorine* E_c	*Carbonyl* E_k	*Hydroxyl*[b] E_h	*Carboxyl*[a] E_a	*Epoxide* E_o	Σ	*Ester group* E_e	*Total carboxyl* E_a'	*Total hydroxyl* E_h'	*Peroxide* E_p
...	Triolein	295	292	1.95	...	...	...	...	...	1.95	1.00	...	...	...
8	Cl_2	339	352	0.01	1.09	0.06	0.21	...	...	1.37	...	...	0.21	...
9	Cl_2	353	351	0.04	1.48	0.08	0.18	...	Nil	1.78	...	0.04	0.22	Nil
10	ClO_2 (gas)	321	259	0.97	0.46	0.45	0.06	0.04	...	1.98	0.91	0.13	0.15	Nil
11	ClO_2 (gas)	312	267	1.45	0.24	0.31	0.11	Nil	0.11	2.22	0.99	Nil	0.11	0.03
12	ClO_2 (aq.)	306	280	1.54	0.16	0.18	0.02	0.02	0.06	1.98	0.86	0.16	0.16	Trace
13	NaOCl	314	285	1.53	0.19	0.29	0.11	0.07	0.05	2.24	0.91	0.16	0.20	0.10
14	H_2O_2	300	280	1.84	...	...	0.07	Nil	0.10	2.01	0.94	0.06	0.13	0.10
...	Methyl oleate	296	...	2.00	...	...	...	...	...	2.00	...	...	...	...
15	Cl_2	336	336	0.67	0.98	...	0.32	...	...	1.97	...	...	0.32	...

[a] $E_a = E_a' - (1.00 - E_e)$.
[b] $E_h = E_h' - (1.00 - E_e)$.

Table IV. Chlorination of Oleic Acid—Analysis and Composition of Reaction Products

Experiment no.	Oleic acid: Solvent	Oleic acid: Approx. conc.	Chlorine: Solvent	Chlorine: Approx. conc.	Order of addition[a]	Rate of addition	Temperature	Iodine number u	Chlorine % c	Hydroxyl % h	Ester meq/gm. e	Neutralization equivalent: Found n_x	Neutralization equivalent: Calculated n	Content of functional groups in equivalents/equivalent of oleic acid: Unsaturation E_u	Chlorine E_c	Hydroxyl E_h	Ester E_e	Σ	Ester: Found	Ester: Calculated[b]
Oleic acid	...	...	...	...	...	...	...	91.5	...	...	...	280	282	...	...	...	...	...	...	...
1	Acetic acid	0.6 *M*	Acetic acid	1.3 *N*	1	Slow	R.T.	7.2	13.7	...	...	364	327	0.19	1.26	...	...	1.45	...	...
2	CCl_4	0.3 *M*	CCl_4	1.7 *N*	1	Slow	R.T.	18.6	12.9	...	0.52	378	324	0.47	1.18	...	0.17	1.82	0.17	0.14
3	$CHCl_3$	1.5 *M*	$CHCl_3$	2.2 *N*	1	Rapid	60°C.	3.8	17.5	...	...	385	342	0.10	1.69	...	0.11	1.90	...	0.11
4	CCl_4	1.5 *M*	CCl_4	2.2 *N*	2	Rapid	77°C.	4.2	18.9	...	0.58	425	348	0.11	1.85	...	0.20	2.16	0.20	0.18
5	$CHCl_3$ 0.13 *M* HCl in	0.1 *M*	$CHCl_3$	1.7 *N*	1	Slow	R.T.	2.8	15.2	...	0.30	375	333	0.07	1.43	...	0.10	1.60	0.10	0.11
6	$CHCl_3$ 0.22 *M* in HCl	0.15 *M*	$CHCl_3$	1.7 *N*	1	Slow	R.T.	11.6	10.2	...	2.81	5130	314	0.28	0.89	...	0.88	2.05	0.88	0.94
7	None	...	H_2O	0.15 *N*	...	...	R.T.	2.9	12.3	2.1	...	418	329	0.07	1.14	0.39	0.21	1.81	...	0.21

[a] 1 = Solution of chlorine added to solution of oleic acid. 2 = Solution of oleic acid added to solution of chlorine.
[b] Calculated from the deviation of the actual n_x from the calculated value n.

For a sample of oxidized triolein, the same relationships hold except that the formula weight of the unmodified oleic acid unit is 295 instead of 282, thus including the alcoholic portion of the ester. The neutralization equivalent, n_x, is of course replaced by the saponification equivalent, s_x, and the calculated formula weight of the oleic acid unit, n, by the calculated formula weight of the oleic ester unit, s. In addition, two further values were used:

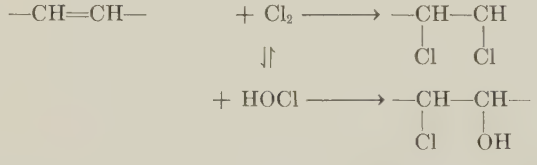
a = carboxyl content in milliequivalents per gram
e = ester content in milliequivalents per gram
$E_a = sa \times 10^{-3}$
$E_e = se \times 10^{-3}$

Results on the saponification behavior of the reaction products are given in Tables V and VI, and the physical properties of some of the modified trioleins are described in Table VI.

DISCUSSION

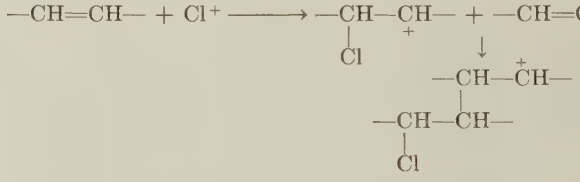
Reaction of Triolein with Chlorine

When triolein is treated with an aqueous solution of chlorine, almost complete saturation of the double bonds occurs. From the analyses of the reaction products, it is apparent that the main reaction is the addition of chlorine to the double bond. Since the products contain appreciable amounts of hydroxyl, some addition of hypochlorous acid, with which the chlorine is in equilibrium in aqueous solution, must also take place.



It is interesting to note that the summation of functional groups is appreciable lower than the theoretical value in both cases. The only reasonable way to account for this loss of double bonds is by polymerization. This view is supported by the viscous character of the product and the high molecular weight obtained in the Rast determination (*cf.* Table VI). It is possible that some polymerization may occur during heating of the product under vacuum to remove the last traces of solvent (*11*). In this respect it should be noted that sample 8, with the lower summation, was heated somewhat more strongly than sample 9, and also stood for several weeks before analysis. Even so, it would be surprising if the rather gentle conditions used for evaporation were responsible for polymerization.

Another possibility is that the polymerization occurred during the reaction. It is known that the initial attack on the double bond during chlorination is by a positively charged chlorine ion. Perhaps the positively charged intermediate is capable itself of attacking another unsaturated position, as shown below:



A highly chlorinated triolein is heavier than water and it has an interfacial tension of 25 dynes per cm. compared with a value of 20 for pure triolein (*cf.* Table VI). It is thus more hydrophobic than triolein and less easily emulsified.

The saponification of both triolein and chlorinated triolein in alcoholic solution was found to be first order with respect to ester group, and almost identical first order rate constants were obtained for both materials (*cf.* Table VI). Thus chlorination of triolein has no effect on the reactivity of the ester group toward homogeneous saponification.

Even in a heterogeneous medium, the rate of saponification is still comparable to that of triolein if the agitation is sufficiently vigorous. Under conditions of little or no agitation, however, the physical properties produced by chlorination are responsible for a very low reactivity (*cf.* Table V).

Table V. Saponification of Reaction Products

Reagent	Per cent saponified under specified conditions: 1% NaOH (agitation)	2% NaOH (no agitation)	5% NaOH (no agitation)
Triolein	18	12	43
Cl_2	14	2	6
ClO_2 (gas)	70	56	88
ClO_2 (aq.)	65	...	...
NaOCl	55	54	63
H_2O_2	55	24	65

Table VI. Physical Properties of Reaction Products

Material	Density, g./ml.	Interfacial tension dynes/cm.[a]	Molecular weight: Found	Molecular weight: Calculated	First order rate constant for homogeneous saponification $hr.^{-1}$
Triolein	0.895	20.0	840	885	0.583
ClO_2–triolein	0.935	17.8	720	935	0.580
Cl_2–triolein	1.062	25.0	1310	1055	0.590

[a] By method of Bartell and Miller (*27*).

In the refining of sulphite pulp, the step which is most effective in removing the extractives, or resin, from the pulp is the hot alkaline extraction. Free acidic materials, of course, can be dissolved and removed in solution, but the only way in which the neutral components of the resin can be removed is by saponification or by dispersion through emulsification. In the alkaline treatment, the original concentration of sodium hydroxide in solution is less than 1%, and this decreases to almost zero during the process. In addition, there is very little agitation of the mixture. Under these conditions, there is likely to be very little saponification of the fatty ester fraction of the resin, even in its natural form. The addition of chlorine to the fatty esters is likely to make deresination even more difficult by reducing their rate of saponification and by increasing the interfacial tension and thus hindering emulsification. For this reason, the use of chlorine in the first stage in bleaching hardwood pulps usually results in a pulp with a very high resin content.

The results of one experiment on the chlorination of methyl oleate are also recorded in Tables II and III. In this case the proportion of hydroxyl groups is higher than in the chlorinated trioleins. This may be due to the use of a more dilute solution of chlorine in which there would be a higher ratio of hypochlorous acid to chlorine. It is interesting that the summation is very close to the theoretical indicating that little or no polymerization has occurred.

Reaction of Triolein with Chlorine Dioxide

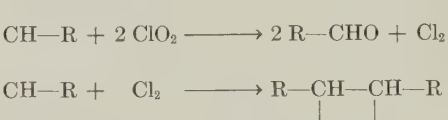
Very little information is recorded in the literature concerning the chemistry of reactions between chlorine dioxide and organic compounds. In 1881 Fürst reacted chlorine dioxide and ethylene in the gaseous phase and isolated monochloroacetic acid from the reaction products (*12*). Later, Schmidt and Braunsdorf tested the stability of a large number of compounds toward chlorine dioxide (*13*). They found that chlorine dioxide attacked both oleic acid and triolein, but did not attempt to study the nature of the interaction. Chlorine dioxide is used as a bleaching agent for flour and fatty oils, and Moran found that the unsaponifiable fraction of flour lipids is most sensitive to the effect of chlorine dioxide (*14*). From a comparison of the composition of the oils from untreated flour and from flour bleached with chlorine dioxide, Fisher concluded that chlorine dioxide has little effect on the essential oils in flour (*15*). On the other hand, it is known that the use of chlorine dioxide in the first stage in the bleaching of hardwood pulps greatly facilitates removal of the resin (*16*). Since hardwood resin consists largely of fatty acids and esters, it seemed likely that some chemical modification of the fat occurs during such a treatment.

From the results shown in Tables II and III, it is apparent that the main reaction between chlorine dioxide and triolein involves the introduction of chlorine and carbonyl groups. Small amounts of hydroxyl and epoxide groups are also present, as well as trace amounts of carboxyl groups in two cases. Actually, in two of the three chlorine dioxide treated trioleins, an appreciable amount of free acid was found (experiments 10 and 12). Since the occurrence of these carboxyls at the double bond positions would have resulted in an unusually high summation, the ester content of the samples was checked. The results showed that most of the free organic acid must have originated from the ester groups of the triolein, presumably by hydrolysis during isolation and purification of the samples. (It is worthy of note that these two samples were in contact with acidic aqueous solutions either during the reaction or isolation of the product, while sample 11, which contains no free carboxyl groups, did not come into contact with water at any time during its history.) The hydrolysis of an ester group produces one hydroxyl group for every carboxyl formed, so that both the total hydroxyl and total carboxyl contents were corrected to give the hydroxyl and carboxyl groups formed by the action of the chlorine dioxide.

The reaction conditions for the three experiments were rather varied. In experiment 10, chlorine dioxide gas was bubbled through the triolein in a reaction tube exposed to the light, and excess reagent was destroyed with aqueous sulphur dioxide. Chlorine dioxide was also bubbled through the triolein in experiment 11, but in this case the reaction tube was kept dark and the excess reagent was removed by a stream of air. Experiment 12 was carried out by shaking triolein with aqueous chlorine dioxide in a separating funnel painted black. Sulphur dioxide was again used to destroy excess chlorine dioxide.

In view of the different conditions employed, it is surprising that the reaction seems to have followed the same course in all cases, with the ratio of carbonyl to chlorine being very close to 1.0. It is rather interesting that a much greater chemical modification of the triolein occurred in experiment 10 than in experiment 11, since the proportion of chlorine dioxide used was almost identical in both cases. The most important difference in the two experiments was the exclusion of light in experiment 11, and this strongly indicates that the reaction is photosensitive and involves free radicals. Chlorine dioxide, of course, contains an unpaired electron itself, and it has been shown to dissociate into oxygen atoms and short lived ClO radicals on irradiation with ultraviolet light (*17*).

A number of reaction paths can be postulated for the reaction between chlorine dioxide and triolein. The one in best accord with the experimental results involves cleavage of the hydrocarbon chain at the double bond with the formation of two aldehyde groups and a mole of chlorine which then adds to another double bond:



In addition to the fact that this hypothesis explains the equimolar proportions of chlorine and carbonyl group in the samples, supporting evidence is supplied by a positive Schiff test obtained on the product of experiment 11. The same sample was also found to have a considerably lower molecular weight by the Rast method than that calculated from its elemental composition (*cf.* Table VI). Unfortunately the accuracy of the molecular weight determination was not reliable enough

to make a decision on the relationship between bonds broken and carbonyl content.

Another interesting fact apparent from Table III is that the saponification equivalent is markedly lower than the calculated value for all three chlorine dioxide-treated samples. Since the method used for determining the saponification equivalent involves titration of the organic acids and not just measurement of the alkali consumed, the low experimental values can only mean that additional carboxyl groups besides those originally present as esters have been formed. The reaction products themselves contain only very small amounts of extra carboxyl, so that most of the carboxyl groups not originating from the ester linkages must have been formed when the sample was refluxed with alcoholic NaOH. These carboxyls, the content of which is equal to $\frac{S-S_x}{S_x} - E_a$, are roughly equal to one half the carbonyl content of the samples.

The mechanism by which these carboxyl groups are produced is uncertain, but several possibilities can be considered. If the reaction path discussed above is correct, then the carboxyl groups are likely to be formed by oxidation of aldehyde groups. A Cannizzaro reaction would account for the observed ratio of carbonyl to extra carboxyl, but is improbable because of the presence of hydrogens on the α-carbon atoms. The only other possibility would be the direct oxidation of part of the aldehyde groups by oxygen present in the alcoholic sodium hydroxide. In this case the apparent 2:1 ratio of carbonyl to carboxyl would be merely fortuitous.

Another structure which could form carboxyl groups on treatment with alkali is the α-diketone, and a free radical mechanism could be postulated for its formation. It could account for the ratio of carbonyl to carboxyl by a benzilic acid rearrangement, although low yields are generally encountered in this reaction when there are hydrogens on the carbon atoms α to the keto groups. The α-diketone structure, however, would not account for the low molecular weight of the reaction product, nor for the presence of chlorine in the material. In addition, tests for the α-diketone grouping were carried out using alkaline peroxide (*18*) and periodic acid (*19*), and the results indicated that any α-diketones could be present in only very small amounts.

On the basis of Fürst's results on the reaction of chlorine dioxide with ethylene, it might be expected that an α-chloro ketone structure would be a likely possibility in triolein. Although a free radical mechanism can also be postulated for the formation of an α-chloroketone, such a reaction does not fit in with the experimental facts as well as the chain cleavage and aldehyde group formation discussed above. If, as seems likely, the reaction is free radical in nature, it is possible that a variety of products are formed, among which might be small amounts of α-diketone, α-chloroketone and epoxide groupings. However, the main reaction is believed to be the formation of aldehyde groups with chain cleavage. Further work is planned to establish this view more definitely.

Two of the three chlorine dioxide-treated trioleins have summations very close to the theoretical values. The product from experiment 11, however, has a rather high summation of 2.22. The reason for this is not clear, although it may be due in part to interference by certain groups, such as peroxide and epoxide, in the analysis for other functional groups (*5*).

Treatment with chlorine dioxide has little effect on the density of triolein, but lowers the interfacial tension against water from 20 dynes per cm. to less than 18, thus making the material more hydrophilic. The reactivity of the ester group toward saponification in solution is not affected since the first order rate constant is almost identical with that for triolein (*cf.* Table VI). In aqueous alkali, however, where the reaction is heterogeneous, the extent of saponification is much greater than for triolein, both with and without agitation. This is undoubtedly due to the relatively easy formation of acidic groups on treatment with hot alkali.

Even under the relatively mild conditions of the hot alkaline extraction used in refining wood pulp, the chlorine dioxide-treated triolein is likely to become much more easily solubilized or emulsified than untreated fats. This will greatly facilitate the removal of hardwood resin and explains the success obtained using chlorine dioxide in the first bleaching stage when refining high resin hardwood pulps (*16*).

Reaction of Triolein with Sodium Hypochlorite

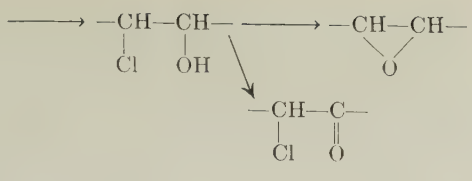
In this case the main reactions seem to be the introduction of carbonyl and chlorine, although not in equivalent proportions. There are also appreciable amounts of hydroxyl and carboxyl groups which did not originate from the original ester groups of the triolein. In addition there is a small amount of epoxide oxygen.

The reaction product gave a positive Schiff test indicating that at least part of the carbonyls are present as aldehyde groups. No molecular weight measurements were made, so there is no direct estimate of the extent of chain breaking. The extra carboxyl groups, of course, could only be formed by a chain cleavage, probably with the intermediate formation of aldehyde groups. Most of the discrepancy between the calculated and experimental values of the saponification equivalent is accounted for by these extra carboxyl groups.

The presence of epoxide is probably due to the primary formation of chlorohydrin groups at the double bond followed by reaction of some of them with sodium hydroxide to form the epoxide. This would also account for some of the chlorine in the sample. Perhaps the remainder of the chlorine is present in α-chloro ketone groups. Some uncertainty is cast on the accuracy of the analysis by the rather high summation of 2.24. The reason for this is not known, but it is possible that the presence of peroxide may have caused high results for the iodine number or carbonyl determinations. When mercuric acetate is used as a catalyst, the iodine number is known to be affected to some extent by the presence of free hydroxyl groups.

From the results of this experiment, the reaction between triolein and alkaline hypochlorite appears to be rather complicated, involving a number of different reactions. The main possibilities are shown below:

$$-CH{=}CH- + NaOCl \longrightarrow 2{-}CHO \longrightarrow 2{-}COOH$$



The reaction product is sufficiently hydrophilic that the extent of saponification in aqueous alkali is considerably greater than for triolein itself. It would therefore be expected that, although not perhaps so effective as chlorine dioxide, a hypochlorite treatment prior to the hot alkaline extraction would be helpful in pulp deresination (*20*).

Reaction of Triolein with Hydrogen Peroxide

The treatment with alkaline peroxide caused less chemical modification of the triolein than any of the other treatments. The main reaction appears to be the introduction of hydroxyl and epoxide groups. An appreciable amount of peroxide is also present. As in the reaction with alkaline hypochlorite, some saponification of the original ester groups apparently occurred. No extra carboxyls were formed since the free carboxyl content is exactly balanced by the decrease in ester content. The reason for the low saponification equivalent is not known, but may be due to cleavage of the α-glycol group by alkali, particularly with peroxide present (*5*).

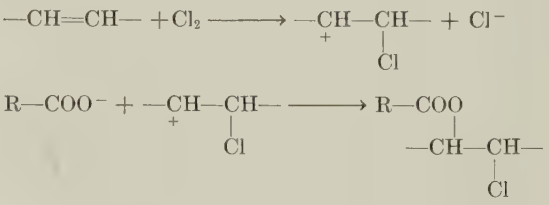
The reaction product is considerably more reactive toward saponification than triolein. Part of this increase in reactivity is undoubtedly due to the presence of free acids which would tend to act as emulsifying agents. This can only be one factor, however, since the hydrogen peroxide-treated triolein is saponified to the same extent as the sodium hypochlorite-treated triolein which contains considerably more free acid. It would be expected that the use of hydrogen peroxide before the hot alkaline extraction stage would be helpful in the deresination of hardwood pulps.

Chlorination of Oleic Acid

There is surprisingly little information in the literature concerning the addition of chlorine to the double bonds of unsaturated fatty acids. Elaidic acid was chlorinated by Piotrowski (*21*) and petroselinic acid by Chernoyarova (*22*) by bubbling chlorine gas into a chloroform solution of the acid. In both cases, products were recovered with close to the theoretical amount of chlorine. More recently, Van Atta (*23*) obtained a good yield of material with the theoretical chlorine content by adding a solution of chlorine in methylene chloride to a solution of methyl oleate in the same solvent at −8°C. to −20°C. Lyness (*24*) bubbled chlorine into a chloroform solution of methyl oleate or oleic acid at −20°C. and got a product with almost the theoretical chlorine content in 100% yield. A mixture of chloroform and acetic acid was also used as a solvent with apparently satisfactory results.

Some time ago, a sample of dichlorostearic acid was required in this laboratory, and an attempt was made to prepare this compound by the low temperature (−10°C.) chlorination of oleic acid in chloroform solution. For some still unexplained reason, the chlorine content of the product was considerably less than 10%.

The reaction was then carried out at room temperature using both carbon tetrachloride and acetic acid as solvents (experiments 1 and 2 in Table IV). The chlorine content of the products was much higher than before, but still not close to the theoretical value of 20.1%. On analysis of the reaction products for chlorine and iodine number, it was found that a substantial proportion of the double bonds could not be accounted for. It was also observed that the experimentally determined value of the neutralization equivalent, n_x, was surprisingly higher than the value calculated from the chlorine content. In other words, some carboxyl group had disappeared during the reaction. The only reasonable hypothesis to explain these results was that some addition of carboxyl anions to the double bond had occurred.



It has been known for many years that if the addition of halogens to olefins is carried out in the presence of other anions than chloride ion, the other anions may appear in the final product (*25*). This possibility does not seem to have been mentioned in the literature dealing with the chlorination of fatty acids. When analyses for ester group were made, their presence was confirmed. In cases where the only other anion beside Cl^- was the oleate ion, the ester content of the sample could be estimated from the difference between the calculated and experimental values for the neutralization equivalent:

$$E_e = 1 - \frac{n}{n_x}$$

In those cases where ester determinations were made, the agreement between the found and calculated values for ester content was good (*cf.* final two columns in Table IV).

No ester determination was made in experiment 1. Since acetate ions were present in addition to oleate ions and in much higher concentration, the calculation for ester content cannot be carried out. This is the main reason for the low summation for this sample. If the assumption were made that all the increase in neutralization equivalent is due to addition of acetate anions to the double bond, the ester content would be 0.62, bringing the summation to 2.07. Probably addition of both oleate and acetate ions occurred. Even taking the ester content into consideration, the summation for experiment 2 is slightly low. The reason for this is not known, unless polymerization occurred, as discussed above under the chlorination of triolein.

Chlorination at higher temperatures increased the chlorine content of the products (*cf.* experiments 3 and 4) without appreciably affecting the ester content. Oleate addition apparently occurred at from 10 to 20% of the double bonds. In experiment 4, the order of addition of reagents was reversed, the oleic acid being added to the chlorine solution. The large excess of chlorine present during the early part of the reaction apparently resulted in some chlorine substitution, as

shown by the high summation of 2.16. It is not known whether substitution occurred in any of the other experiments since the summations are (with one exception) less than 2.0.

A couple of experiments were done to see whether the presence of hydrochloric acid would increase the chloride ion concentration sufficiently to eliminate or reduce the addition of oleate ion. The product of experiment 5 showed no marked improvement in this respect, and, in addition, the summation was only 1.60. The reason for this low value is not known. It seems unlikely that addition of hydrochloric acid to the double bond can have occurred, since it is well known that this reaction is very slow (*21*). It should perhaps be noted that a low summation cannot be due to failure to remove all of the solvent, since the error caused by the high chlorine content of the solvent would more than make up for any dilution of the sample.

Experiment 6 was also carried out in the presence of hydrochloric acid, under conditions very similar to those of experiment 5. The ester content is almost unbelievably high, but again the agreement between found and calculated values of ester is fairly good. The summation is also very close to the theoretical. The only apparent difference between this sample and the product of experiment 5 is that the former stood for almost two months before the analysis was completed. Unless condensation occurred during solvent evaporation or storage, with the consequent elimination of hydrochloric acid, this result is very difficult to explain.

The results of one chlorination of oleic acid in aqueous medium are also included in Table IV (experiment 7). In this case hydroxyl addition occurred to a considerable extent. It is well known that hypochlorous acid, with which the chlorine would be in equilibrium in aqueous solution, adds easily to the double bonds of unsaturated fatty acids (*26*). From the neutralization equivalent, it is calculated that 21% of the carboxyl groups are involved in ester group formation through addition at double bonds. The summation of 1.81 is somewhat low as in the cases of the reaction between aqueous chlorine and triolein.

EXPERIMENTAL

Materials. The oleic acid used was U.S.P. grade supplied by Fisher Scientific Co. with an iodine number of 91.5. Triolein was prepared by the method of Wheeler (*1*), and purified by fractional crystallization from acetone (iodine number 84.0, density at 23°C. 0.895). Methyl oleate was prepared by the esterification of oleic acid in 5:1 methanol: sulphuric acid.

Reaction with Chlorine. Triolein (50 g.) was shaken with 3 l. of a 0.5% solution of chlorine in water at room temperature. Excess chlorine was destroyed by addition of sulphur dioxide and the reaction product was recovered by extraction with ether. The ether solution was thoroughly washed with water, dried over sodium sulphate and evaporated on a steam bath. Final drying was under vacuum at a temperature of 40 to 50°C. (yield 56.3 g. of a light yellow, viscous oil). Similar procedures were used for oleic acid and methyl oleate.

Reaction with Chlorine Dioxide. Chlorine dioxide was available in the form of a stock solution made on a pilot plant scale for pulp bleaching by the reduction of sodium chlorate with sulphur dioxide. The concentration of chlorine dioxide was *ca.* 1.5 g.p.l. and the pH was 2.5. (a) In experiment 10, air was drawn by suction through a stock solution and then through a column of sodium chlorite to remove any chlorine. The gas containing chlorine dioxide was bubbled through triolein in a test tube. During this treatment, the triolein turned a bright yellow color and the temperature of the mixture rose to about 40°C. After about 1 mole of chlorine dioxide per oleic acid unit had been added, the temperature dropped again. Sulphur dioxide was passed in to destroy excess reagent, but the yellow color persisted. The product was taken up in ether, washed with water and recovered in the usual way. In experiment 11, the reaction was carried out in the same manner, but in the dark, and the reaction product was purified by bubbling dry air through it. (b) In experiment 12, the triolein was shaken with an aqueous solution of chlorine dioxide in a separating funnel. The molar ratio of chlorine dioxide to oleic acid was slightly greater than 1:1. The excess reagent was destroyed with sulphur dioxide and the product was taken up in ether and purified in the usual manner. During evaporation of the solvent, the product turned a light yellow-brown color. Procedure (b) was used in treating methyl oleate as well.

Reaction with Sodium Hypochlorite. The triolein (15.6 g.) was shaken intermittently with 250 ml. of 0.8 *N* NaOCl for 3 hr. at 65°C. and pH 11.7. The reaction was carried out in a 500-ml. flask fitted with a stopcock (to equalize the pressure) and heated on a hot plate. After the reaction mixture had been cooled, sulphur dioxide was added and the product was taken up in ether. (Yield 14.4 g. after some mechanical losses. In another experiment, 4.98 g. of product were recovered from 4.70 g. oleic acid)

Reaction with Hydrogen Peroxide. Triolein was reacted with a 3% aqueous solution of hydrogen peroxide at 65°C. for 3 hr. in the same way as for the reaction with hypochlorite. The pH was 10.9 and the molar ratio of hydrogen peroxide to oleic acid was *ca.* 2:1. Recovery of the product after addition of sulphur dioxide was the same as for the other experiments. Because of mechanical losses, no figures for yield were obtained.

Chlorination of Oleic Acid in Organic Solvents. The details of these reactions are given in Table IV. Recovery of the products was carried out simply by evaporation of the solvent concerned, followed by drying under vacuum.

Homogeneous Saponification. The sample (0.2 g.) was dissolved in 90 ml. *n*-butanol and brought to 25° C. in a constant temperature bath. Alcoholic potassium hydroxide (10 ml. of 0.5 *N*) was added, and 5 ml. aliquots were taken at 30-min. intervals for ester determination.

Heterogeneous Saponification. (a) The sample (0.5 g.) was weighed into a 125-ml. flask to which was added 25 ml. of 1% NaOH at 95°C. The mixture was refluxed gently on a hot plate and stirred vigorously with a magnetic stirrer for 3 hr. The reaction products were separated into neutral and acidic fractions using con-

ventional procedures. (b) The sample (0.5 g.) was weighed into a test tube and 10 ml. of either 2 or 5% aqueous NaOH were added. The mixture was heated on the steam bath for 3 hr. with only occasional mixing by shaking the tube. The neutral and acidic fractions were recovered in the normal way.

Analytical Methods. Iodine number was determined by a modification of the Wijs method using mercuric acetate as a catalyst and a reaction time of 5 min. (*2*). Chlorine was determined by a modification of the method of Sisido and Yagi (*3*), using the mercuric nitrate titration of Thomas (*4*). Analysis for carbonyl was according to the procedure of Knight and Swern (*5*). Hydroxyl determinations were made by the acetylation procedure of Ogg, Porter, and Willits (*6*). Saponification and neutralization equivalents were measured by the method of Marcali and Rieman (*7*). Analysis for epoxide was by the method of Swern (*8*), and peroxide determinations were carried out using the micro method of Lemon (*9*). The colored complex formed by iron with hydroxamic acids was the basis of a spectrophotometric method for determination of ester group, as described by Goddu (*10*).

The pulp resin referred to in Table I was analyzed by a modification of the fractionation method of Hibbert and Phillips (*28*). Separation of the difficultly esterified acids, or "resin acids," from the fatty acids was carried out by the method of Wolff and Scholze (*29*). The spectrophotometric technique of Brice and Swain was used to analyze the fatty esters (*30*).

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Development of a Print Smoothness Tester for Paperboard

T. G. ZENTNER

A print smoothness tester has been developed for testing paperboard in development and mill control work. Although the print tester is essentially a bench model gravure press and employs the gravure principle, it has value in predicting letterpress printability as well as gravure printability. Special design features in the press provide the necessary ease of operation for routine testing.

In recent years the printing quality of board has shown marked improvements. Today, folding cartons are being produced with printing qualities equal to the best in the printing industry. Much of this progress has come about through the introduction of gravure and lithographic printing of board. Along with this has come an increasing demand for smoother board surfaces, especially when the board is printed by the gravure process. The testing of board smoothness has necessarily been an important consideration. The purpose of this paper is to describe a print smoothness tester designed for use as a development and mill control instrument.

Printing smoothness can be defined as the degree of conformity under printing pressure of a board surface to the inked printing plate. Lack of conformity leads to incomplete ink transfer and, therefore, loss of detail in the printed copy. The inked image in offset lithography is carried on a rubber blanket. The compressibility of the rubber aids in the conformity during printing, and explains why rougher boards can be commercially printed by the offset process.

In the gravure process, ink is carried in very small wells. The normal gravure screen utilizes cells that approach the diameter of papermaking fibers. Any lack of continuity of the board surface (e.g., spaces between fibers or wire marks) which approaches the dimensions of gravure cells can cause misses in the printed image. These objectionable misses are referred to in the printing trade by a number of terms such as "snowflaking" or "salt and pepper."

The photographs in Fig. 1 show gravure prints with varying degrees of missing dots. It is apparent that dot misses occur mainly in areas when the lightest tones are printed. This is to be expected because there is a greater probability of a small cell failing to contact the board surface. Also, the cells used to print the

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Fig. 1. Production gravure press prints showing different degrees of missing dots

shadow tones and solids are much deeper. This allows the ink to flood the entire surface and to flow into depressions that are out of contact.

Unlike some properties of board, printing smoothness cannot be generally predicted by routine visual examination of the surface. Because of size, the defects under consideration are usually visible only when viewed with magnification, and such viewing does not take into account the compressibility of the surface.

To overcome the problems related to visual estimation of smoothness, various investigators have developed instruments for measuring smoothness. The most common instruments are based on indirect measurements of the surface out of contact and involve resistance to air flow (1) or optical contact (2). It is believed that both of these types of measurements can be influenced by very small surface irregularities that will not cause dot misses in gravure printing. In addition, the porosity of the board is known to affect air flow measurements. The failure of these instruments to correlate with gravure printing necessitated studies to develop other methods for measuring printing smoothness.

Another approach to the measurement of printing smoothness has involved actual printing tests using standardized conditons. Using this approach, Eckhart, *et al.* (*3*) have developed reproducible letterpress printing techniques that allow the numerical rating of board smoothness. The technique does require extremely accurate control of ink film and impression, and this has hindered its application in routine mill control work. However, the advantages of using a direct measurement of printing smoothness does have merit, and has prompted the consideration of using printing techniques to measure printing smoothness.

Preliminary trials with a small gravure proof press indicated that the gravure process has several inherent advantages that lend themselves to use as a control printing test. These advantages are:

1. The ink film remains constant for a series of prints without the need for adding make-up ink.
2. Pressure is obtained by spring or air loading rather than by clearance. Adjustments in pressure are not necessary for changes in caliper.
3. A minimum of moving parts allows simplicity in design and low maintenance.

Based on these advantages, a decision was made to design and build a print smoothness tester using the gravure principle. The preliminary work indicated that board testing would require several special features. First, it was noted that the tester should be rugged in order to withstand the high pressures required for board printing. Commercially available gravure proof presses normally used for paper were found to be inadequate in this respect. It was also decided that the press should be capable of printing sheets of board rather than rolls. Most of the available proof presses were designed to print from rolls. Finally, it was decided that a non-volatile ink should be used to prevent explosion hazards, and to eliminate changes in the ink due to solvent evaporation.

PRINT SMOOTHNESS TESTER

Photographs in Fig. 2 show the latest model of the print smoothness tester. Photograph A shows the tester from the feed board side being operated by a mill inspector. Photograph B shows the tester from the delivery side.

The tester consists of a single gravure printing unit with a feed table and delivery table for conveniently

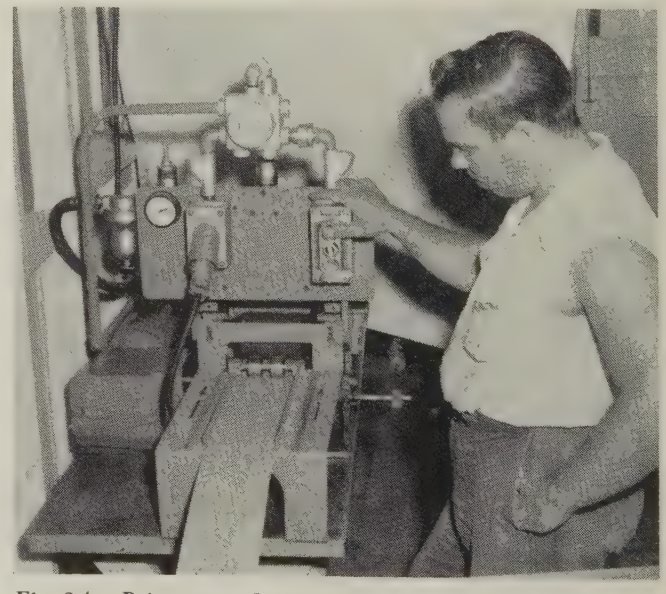

Fig. 2A. Print smoothness tester showing the operation—front view

handling board. The chrome-plated printing cylinder is 4 in. in diameter with a face of 6 in. The impression cylinder is covered with a 90 Shore A Durometer rubber which is normally used for commercial board printing.

The print cylinder is partially immersed in a tray of nonvolatile ink which can be easily lowered to facilitate cleaning. An oscillating doctor blade provides a clean wipe, and eliminates the problem of localized wear on the printing cylinder.

The impression cylinder is loaded with two air cylinders (photograph B). A pressure regulating valve allows the control of pressure at the desired level. The press is driven by a $^1/_2$-hp. synchronous motor. A gear reduction provides an operating speed of 220 f.p.m.

Operation of the Tester

The print tester is both easy and rapid to operate. The operation consists of first rotating the printing cylinder for approximately 1 min. to insure that the cells are wetted with ink. The cylinder is stopped and a strip of board 5 by 36 in. is placed face down on the feed board. The long sheet is used to insure that printing has come to equilibrium. Prints obtained after the second revolution of the cylinder are reproducible. The lead edge of the sheet is allowed to extend into the open nip between the printing and impression cylinder. The impression cylinder is lowered and the press is then started. (It is assumed that the air pressure has been previously set at the desired level.) The sheet is pulled through the press and delivered on the back table. The impression cylinder lifts automatically, thereby preventing ink from transferring to it. This is accomplished through the use of a microswitch located on the feed board. When the end of the sheet passes over the switch, a solenoid valve in the air line is deactivated and the impression cylinder lifts.

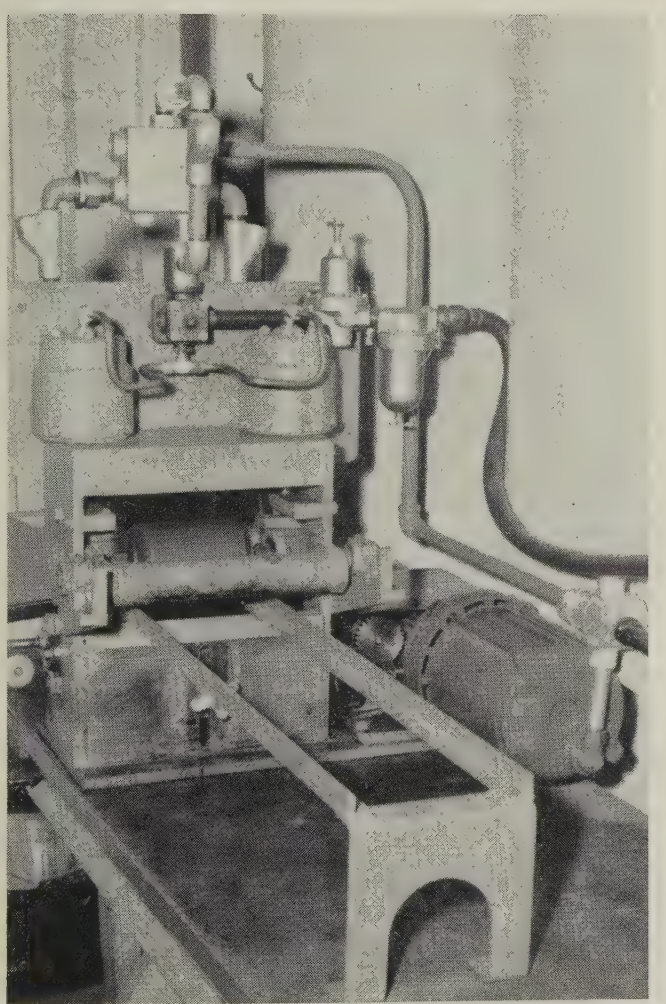

Fig. 2B. Print smoothness tester showing the delivery section

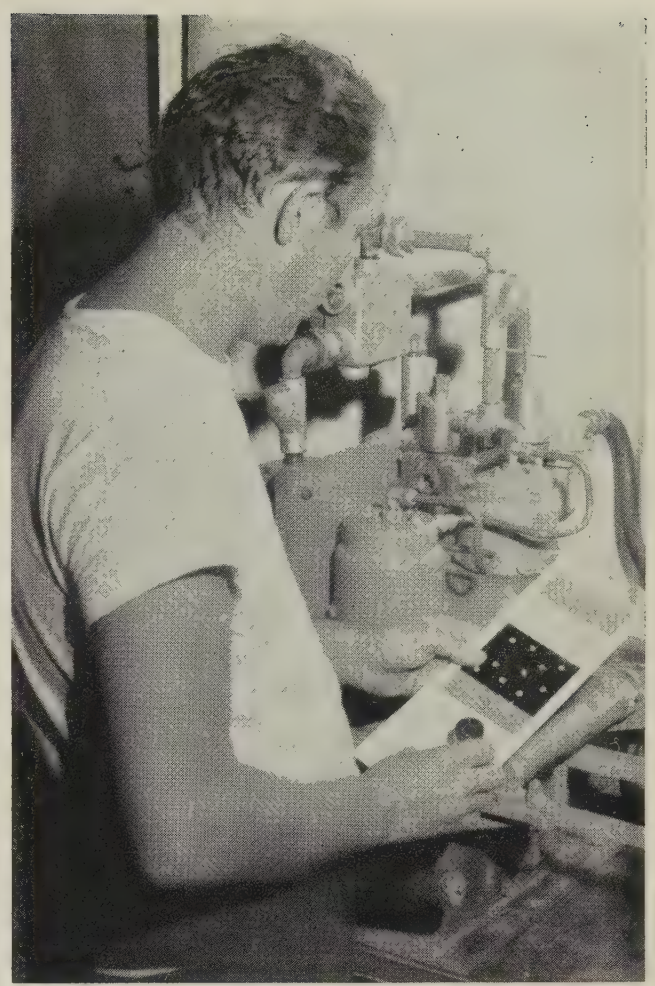

Fig. 3. Mill inspector using template counting technique

Maintenance of the Testers

Two print smoothness testers have been in operation in different mills for several months and have required little maintenance. Although the testers were operated for several weeks without any attention, a practice has been started to change the ink at weekly intervals. This is done to insure that dust particles that collect will not eventually damage the printing cylinder. The ink pan can be reached easily by removing the feed board.

It has been necessary to replace the doctor blade at intervals of approximately one month. The frequency depends upon the amount of use. Some care is required in replacing the blade to insure that the blade is dressed properly. Fitting the blade to the printing cylinder is accomplished by two adjusting screws at either end of the blade holder. After a blade has been changed, it is necessary to rotate the cylinder for approximately one hour to insure that the blade is worn in.

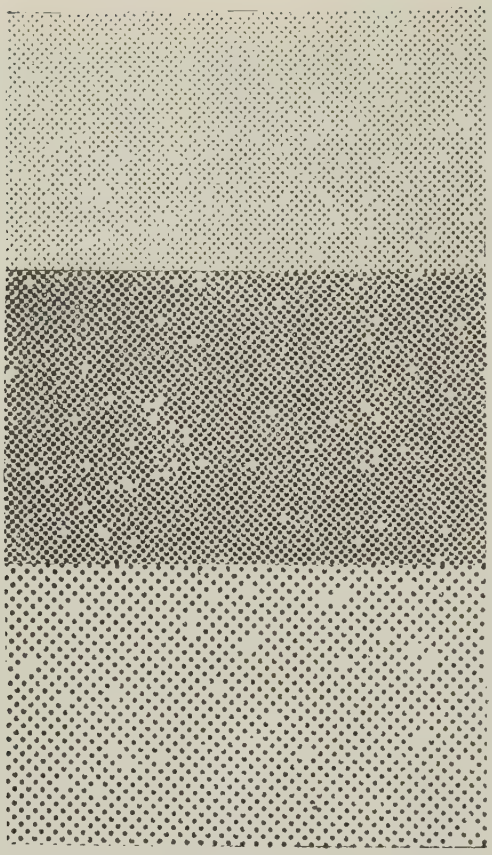

Fig. 4. Prints using different cell and screen sizes (× 7)

A—(Top) 150-line screen, 50-mu cell. B—(Center) 150-line screen, 100-mu cell. C—(Bottom) 100-line screen, 100-mu cell.

It is expected that the printing cylinders will eventually wear and require attention. Unless the cylinder has been damaged, it is felt that rechroming will be sufficient.

MEASURING PRINT SMOOTHNESS

It was originally intended that prints made on the tester be graded by visual comparison with standards. This involves comparing the apparent number of dot misses in a halftone print with prepared standards. Although this is very rapid and can be used to show gross differences between boards, there are disadvantages in using this technique for routine control work. The main fault is that prints will have differences in appearance depending upon the absorbency of the stock. A very absorbent uncoated board will produce enlarged dots because of ink spreading, and misses will be less apparent. Another problem is that differences in brightness cause more or less contrast with the printed dots, thus producing different visual effects. In order to relieve the test operator of the problems of visual judgment, a means for direct measurement was devised.

An obvious approach was to actually count the number of dots missing in each print. Because the count becomes quite high on some boards, a template was devised with random holes to allow coverage of a larger area with less actual counting. A magnifying glass can be used to aid in counting dot misses in each hole of the template. The photograph in Fig. 3 shows an inspector using the template counting technique.

There was some problem in determining the number of holes and total area to be counted to define the printing quality of a sample. This was resolved in the following manner. By observing commercial printed samples, it was noted that dot missing is most apparent when the eyes focus on an area of approximately 4 to 6 sq. in. From this it was decided that a test sample should be near this size.

The next problem was to determine the per cent of the total area to be counted in order to define the sample with sufficient precision. This was answered again through examination of commercial prints. It was noted that prints appear commercially different when the number of dot misses differ by approximately 100%. Therefore, in order to insure that the counting technique would distinguish between commercially different samples, it was required that the standard deviation of individual determinations be no greater than 25% of the mean. Several different templates were tested using different boards. The final template chosen contains 20 holes and a total area of 1 sq. in. The holes are square and are aligned to coincide with the screen angle of printed dots.

The large area to be counted is necessitated by the nature of the dot missing on boxboard. Missing of dots is not generally random. Evidently because of formation patterns, areas of perfect smoothness can vary from $^1/_{16}$ to $^1/_4$ in. square. In other words, the missing of dots is often concentrated in small areas, and this depends upon formation or other patterns in the board surface.

DEVELOPMENT OF THE PRINTING CYLINDER

The first print cylinder was etched using a 150-line screen. Patches with different size dots were etched on the cylinder to cover the range of halftone high light printing. Cell diameters varied from 50 to 100 mu. It was known that the number of misses would differ depending upon the size of the cells. The problem was to choose a cell size that would be sufficiently small to show differences in board, but of maximum

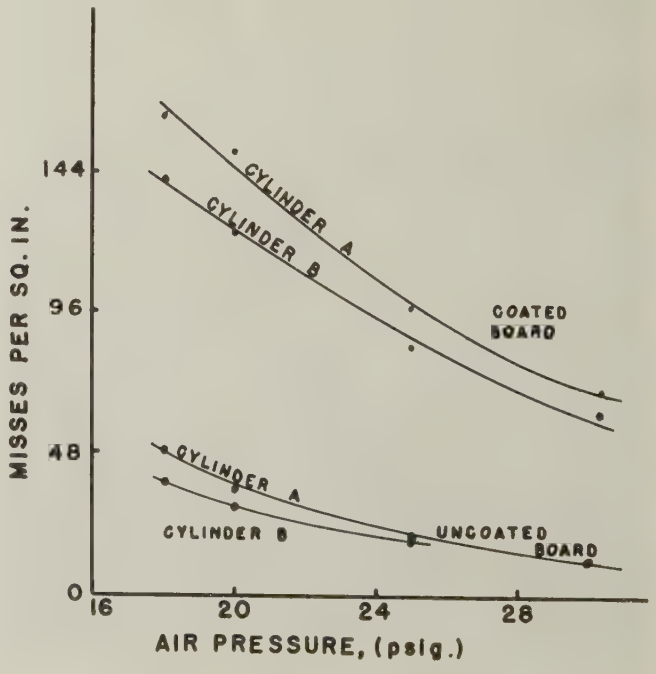

Fig. 5. Dot missing is affected by printing pressure

size to reduce the amount of counting. It was found that the order of rating different boards remained essentially the same whether a 50 or 100-mu cell was used. Since the larger cell was preferred, it was chosen. However, it was noted that 100-mu cells in a 150-line screen are very close together, and it is difficult to distinguish them. The cylinder was then changed to the use of a 100-line screen which gave more space between the cells. With this screen it is possible to count dot misses without magnification.

The photographs in Fig. 4 show prints using different cell and screen sizes. Photograph A is a 50-mu cell with a 150-line screen; photograph B is a 100-mu cell with a 150-line screen; and photograph C is a 100-mu cell with a 100-line screen.

The dependence of the number of dot misses on cell size makes the cylinder preparation requirements extremely exacting. This requirement presupposes that standardization between print testers is desirable, and the use of different cylinders over a period of time should not cause changes in printing standards. Fortunately, procedures have been established for producing cylinders with the required precision. The procedures established by the Yoder Engraving Co., Middletown, Ohio, are based on the use of a hard dot positive and a duPont Rotofilm resist. By controlling the temperature and concentration of the ferric chloride etchant, an etching time has been established to produce the desired size. Even the chrome-plating must be accurately controlled to insure precise results. The following data show the print test results

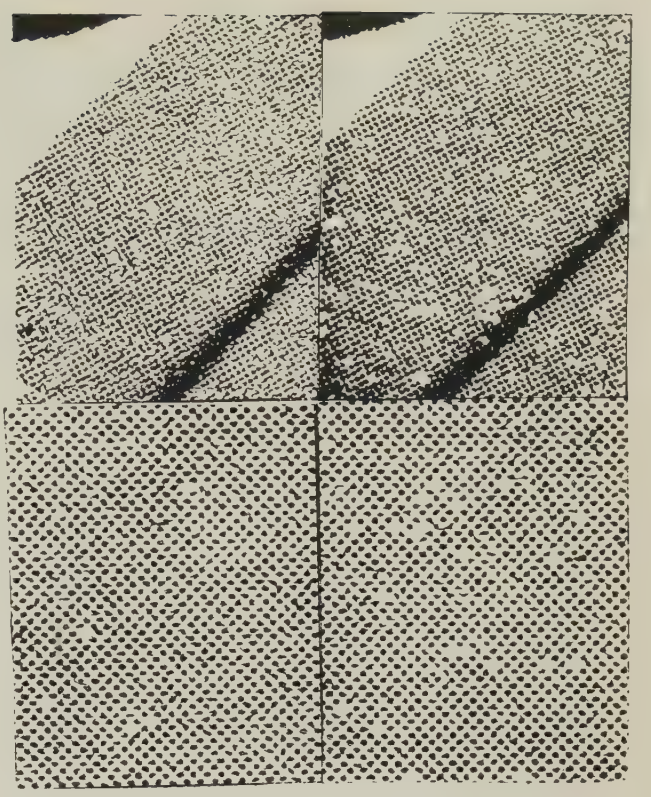

Fig. 7. Comparison of print test results and gravure monotone printing on uncoated boards (× 7)

A—(Upper left) production printing on board A. B—(Upper right) production printing on board B. C—(Lower left) print test on board A. D—(Lower right) print test on board B.

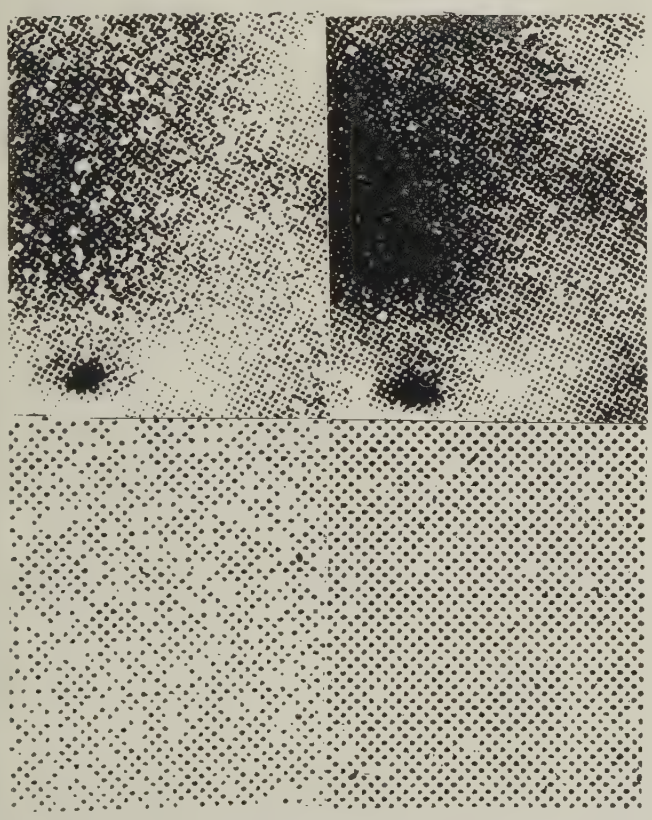

Fig. 6. Comparison of print test results and four color gravure process printing on coated board (× 7)

A—(Upper left) process printing on board A. B—(Upper right) process printing on board B. C—(Lower left) print test on board A. D—(Lower right) print test on board B.

using a cylinder that had been chromeplated under two different conditions. The cell diameter in cylinder A was 95 to 100 mu, while the diameter was 100 to 105 in cylinder B. Printing with these cylinders at 20 lb. gage pressure produced an average of 151 misses per sq. in. with cylinder A and 123 misses per sq. in. with cylinder B using a standard board.

Provided the differences in cylinders are not great, it is possible to adjust printing pressure to allow for the difference. The curves in Fig. 5 show that an adjustment in air pressure of approximately 2 lb. per sq. in. will produce equivalent results with cylinders A and B.

COMPARISON OF PRINT SMOOTHNESS RESULTS AND COMMERCIAL GRAVURE PRINTING

The first step in comparing the print smoothness results with commercial gravure printing involved establishing comparable printing pressures. This was accomplished by making carbon paper impressions with the print tester using different pressures, and then comparing these with impressions obtained on a production press. It was found that an air pressure of 20 p.s.i.g. on the print tester gave results comparable to normal production impression. Nip pressures were calculated for the production press and the print tester and found to be 330 and 310 p.s.i., respectively.

The results of the print smoothness tester were compared with commercial printing by first collecting a cross section of various gravure production runs. The unprinted glue flaps from these cartons were printed with the print tester. Comparisons indicated excel-

lent agreement between production printing and the print smoothness tester. The photographs in Figs. 6 and 7 show typical samples used in the comparisons. Figure 6 shows a comparison made with a four-color process job on two different coated boards, while Fig. 7 shows a comparison with a monotone job on uncoated boards.

The comparisons made it possible to set tentative specifications for different production jobs. These specifications varied from an allowable 360 misses per sq. in. to 25 misses per sq. in. and represent jobs with extremely different quality requirements.

COMPARISON OF PRINT SMOOTHNESS TEST RESULTS AND LETTERPRESS PRINTING

Although the print smoothness tester was originally intended to be used to measure gravure printability, there was considerable interest in determining the correlation with letterpress printability. Unfortunately, the comparisons with letterpress could not be made as straightforward as the comparisons with commercial gravure printing. This is primarily because letterpress defects caused by board roughness appear mostly in the middletones and solids. Visual comparisons are therefore difficult because appearances are different.

There are also problems in defining a test for letterpress print quality. The technique used in this study involved comparing the amount of impression required to produce a satisfactory print. Where precise measurements are required, it has been recommended that actual pressures be measured during the printing (*4*, *5*). It is felt that letterpress printing at equal pressures would be more comparable to the results obtained with the print smoothness tester because this instrument maintains constant pressure.

In spite of these problems, there appears to be fair agreement between print test results and letterpress printability. The agreement is excellent where grossly different boards are involved. This can be seen by the photographs in Fig. 8 where comparisons are made on four widely different coated boards. The letterpress printing involved the use of a diagonal line plate at constant impression. The boards varied from a cast coated board (photograph A) to a fairly rough air knife coated board (photograph D).

THE PRINT SMOOTHNESS TESTER AS A MILL CONTROL INSTRUMENT

The print tester was designed primarily to be useful as a mill control instrument. After several months of operation in mill control stations, it has been established that the tester can be operated on a routine basis with minimum attention. However, this has required the establishment of standards. To do this, two lots of board were arbitrarily selected and a cross section from each was tested. Means and standard deviations were determined for each lot. At weekly intervals, five samples are tested and the results are checked to insure that the test instrument is in control.

DISCUSSION

The print smoothness tester described in this paper was designed specifically to predict gravure printing smoothness. Because there are many degrees and kinds of surface irregularities that enter into technical considerations of board smoothness, it is well to emphasize the limitations of this tester. For example, the kind of irregularities that are known to affect the surface gloss are probably out of the realm of this print smoothness tester.

The major limitation of the print smoothness tester is involved in the fact that smoothness results are expressed in terms of missing dots. Because the dots are approximately 100 mu in diameter, the smoothness results are actually a measurement of the number of surface depressions larger than 100 mu. There is no indication of the depth of the depressions, although the tester shows that the depression exists even under

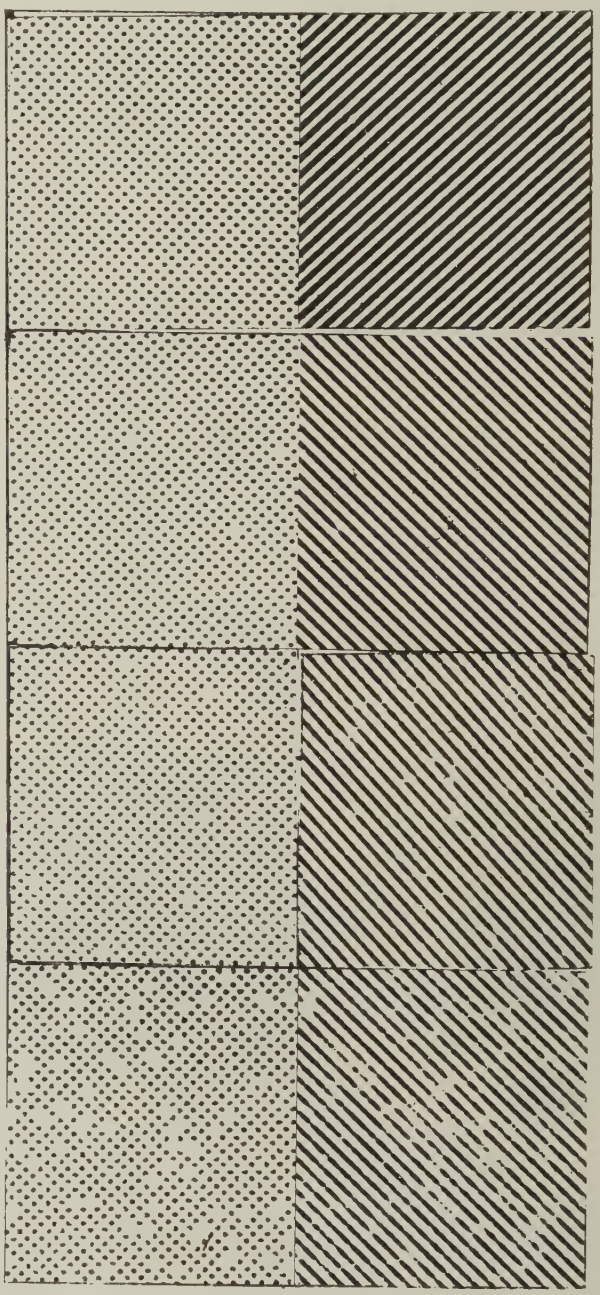

Fig. 8. Comparison of print tests and letterpress printing on different coated boards (print test left side—letterpress right side) (× 7)

A—Cast coated board showing excellent printing. B—Very slight roughness. C—Intermediate roughness. D—Extreme roughness.

normal printing pressures. With this limitation in mind, its implications in predicting printing smoothness will be considered.

In the gravure process, it is felt that the print tester is not limited in its application. This is mainly because the tester employs the gravure principle. The print tester does contain a gravure cell somewhat larger than the smallest used in commercial gravure printing, but evidently this relative difference is not significant.

In predicting letterpress printability, the print tester may have certain limitations even though the results presented in this study show fair correlation. It is apparent from the photographs in Fig. 9 that defects larger than 100 mu will be shown by the print tester, as well as by letterpress. (The photographs were taken with side lighting and with sufficient magnification to show both the board surface and the printing.) These photographs show the large felt marks in this particular board surface to affect both types of printing. This apparent agreement is also shown by the photographs in Fig. 10. Although the depressions are considerably smaller, they are sufficiently large to cause dots to miss and the letterpress lines to break. However, it can be noted that the letterpress print (photograph A) also shows some constriction of lines where a very small depression is printed. It is doubtful that the print tester would show a dot miss in such areas. Although the narrowing of a letterpress line would not be so objectionable as a line break, this does illustrate that defects can occur in letterpress printing without being distinguished by the print tester. An obvious approach to eliminating this discrepancy would be to

Fig. 9. Effect of surface defects on print test and letterpress printing—very rough board (× 15)

A—Letterpress (left). B—Print test (right).

reduce the size of the gravure cell used in the print tester. This may become necessary if it is found through further testing that the print tester does not show commercial differences between better grades of letterpress boards.

There is one additional difference between letterpress printing and the print tester that should be noted. The print tester registers a miss regardless of the depth of a depression. In letterpress printing, the ink film is of sufficient thickness to flow into shallow depressions. The effect of this difference is not known. One

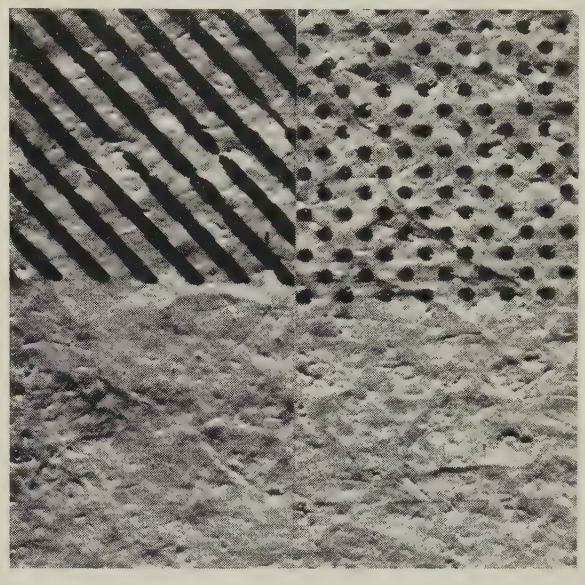

Fig. 10. Effect of surface defects on print test and letterpress printing—slightly rough board (× 15)

A—Letterpress (left). B—Print test (right).

might speculate that this difference would allow letterpress to print certain depressions that might cause misses with the print tester. On the other hand, it could be argued that many of these depressions are minute holes and crevices that are not part of the smoothness picture one normally considers. In other words, the depressions known to be detrimental to good letterpress printing (e.g., wire marks, felt marks, etc.) are of sufficient depth to prevent coverage by an ink film that would be recommended for fine letterpress printing.

CONCLUSIONS

1. A point smoothness tester has been developed that can be used to predict board smoothness essential for the gravure printing process.

2. The tester can be operated as a routine control instrument with sufficient precision to detect commercial quality differences in board.

3. The tester has shown value in predicting letterpress printing smoothness although additional work is needed in this area.

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Various people in the Gardner Division of the Diamond Gardner Corp. participated in the development of the print smoothness tester. The writer is also grateful to S. Trosset for preparing the photographs necessary for the presentation of this paper.

Presented at the Ninth Testing Conference of the Technical Association of the Pulp and Paper Industry, Savannah, Ga., Sept. 30–Oct. 3, 1958.

An Apparent Viscosity for Use in the Application of Reynolds Numbers to the Flow of Dilute Pulp Suspensions

W. E. GUTHRIE

The material presented in this report describes a generalized Reynolds number equation that is applicable to non-Newtonian as well as Newtonian fluids. The experimental data prove the validity of this equation and shows a relationship between per cent consistency of pulp slurries and apparent viscosity which is applicable when the generalized Reynolds equation is used. This method of calculating Reynolds numbers should be of considerable value in future work on headbox design and pipe flow problems in the paper mill.

THE Reynolds number of a fluid is a dimensionless number which is of considerable value in analyzing the behavior of existing hydraulic systems and in the design of new ones. Heretofore it could only be accurately calculated for Newtonian fluids such as water in which no solid particles were in suspension.

The purpose of this report is to present data from experiments to determine the validity of a recently published method of calculating Reynolds numbers for non-Newtonian fluids when the method is applied to pulp slurries.

The practical application of the material presented in this report will be a more accurate method of determining proper diameter piping and pump capacity required to transport pulp slurries. Also, since the Reynolds number is an indication of the intensity of turbulence in a moving fluid it will be of considerable value in studying flow in paper machine headboxes where turbulence is a very important factor. It is desirable to operate a paper machine headbox with sufficient turbulence to prevent fiber flocculation without producing eddies which result in streaky formation as the sheet forms.

A knowledge of the Reynolds number under different operating conditions will be of considerable value in determining the optimum operating conditions.

The method of calculating Reynolds numbers of non-Newtonian fluids which was devised by Metzner and Reed (*1*) has been found to be valid for paper pulp slurries of 0.5 to 2% consistency over a range of Reynolds numbers from 300 to 70,000 and a range of fiber lengths of 0.20 to 0.67 mm. as determined by the Kane method (*3*).

A correlation between per cent consistency and apparent viscosity has been obtained which will allow the direct calculation of Reynolds numbers over the consistency range of 0 to 2.0%. The Fanning friction factors can then be determined from the conventional Reynolds curve for Newtonian fluids published in most engineering handbooks.

WILLIAM E. GUTHRIE, Development Engineer, Paper Service Div., Eastman Kodak Co., Rochester, N. Y.

APPARATUS

A diagram of the apparatus used in this experiment is shown in Fig. 1. It consists of a 50-gal. pulp storage tank (A), lightning mixer (B), recirculationg pump (C), $^1/_2$ and 1-in. copper tubing each approximately 15 ft. long (D), equipped with a globe valve (E) on the upstream end and a short length of tygon tubing with a pinch clamp (F) on the downstream end. The $^1/_8$-in. I.D. pressure taps (G–J) were located according to A.S.M.E. Standards and soldered into the pipes in such a manner that the inside of the pipe was smooth and free from burrs. They were connected to the bottom of the pipe so that any entrained air would be less likely to contribute error in the pressure readings. The taps on each pipe were connected to separate manometers (K) filled with tetra-bromo-ethane (sp. gr. 2.95) which had been colored with a water-insoluble red dye.

PROCEDURE

The equipment was filled with water and care was taken to eliminate air in the lines to each manometer. The shut off valves at each end of the pipe lines were then closed and the water was drained from the storage tank and replaced with a 2% pulp slurry. The recirculation pump was started, the upstream and downstream valves on one of the pipes were opened and the pulp slurry replaced the water in the pipe line without allowing any air to enter the system. The flow rate was controlled by the downstream throttle valve and measured volumetrically by means of a calibrated container and a stop watch. The pressure drop in the pipe line was determined for at least 10 different flow rates. The pipe line was then closed off with care being taken to keep the pipe full so air could not enter the system. The flow rates and corresponding pressure

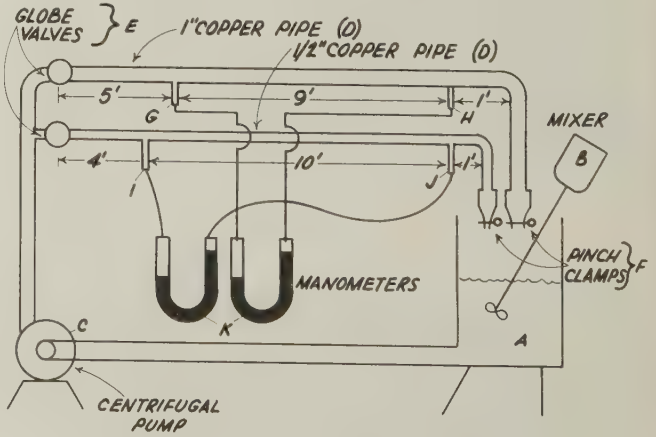


Fig. 1. Diagrammatic sketch of apparatus

NOMENCLATURE

D = inside pipe diameter, feet
f = Fanning friction factor = $\frac{D\Delta P/4L}{\rho V^2/2g}$
g = conversion factor = 32.2 feet per second-squared
K' = coefficient of consistency (pounds force) (second $^{n'}$/square feet)
L = length of pipe, feet
n' = dimensionless exponent
N_{re} = Reynolds number, dimensionless $N_{re} = D^{n'}V^{2-n'}\rho/\gamma$ for all fluids which reduces to $DV\rho/\mu$ for Newtonians
M = hydraulic radius = cross-sectional area of channel/wetted perimeter
ΔP = pressure drop, pounds per square feet
Q = volumetric flowrate, cubic feet per second
V = average velocity, feet per second
γ = generalized viscosity coefficient as defined by equation $\gamma = gK'(8)^{n-1}$
μ = viscosity of a Newtonian fluid, pounds mass/foot second
ρ = density of fluid (pound mass/cubic feet)

drops were then determined in the second pipe after which it was closed off and the consistency in the supply tank was diluted for the next series of runs. The pulps used in the experiment were mixtures of bleached softwood sulphite and bleached softwood kraft.

DISCUSSION

The nature of fluid flow, whether laminar or turbulent, and the extent of friction which results in pressure drop are determined by the dimensionless ratio $MV\rho/\mu$ which is commonly known as the Reynolds number. The parameters involved in this ratio are fluid velocity (V), density (ρ), viscosity (μ), and hydraulic radius (M). The hydraulic radius is the ratio of cross-sectional area to wetted perimeter of the conduit in which the fluid is flowing. In the case of a circular pipe M reduces to D the pipe diameter.

The Reynolds number is usually one of the first things to evaluate in any study of fluid flow. Heretofore it could only be used in the study of Newtonian fluids, such as water, which did not contain any solid

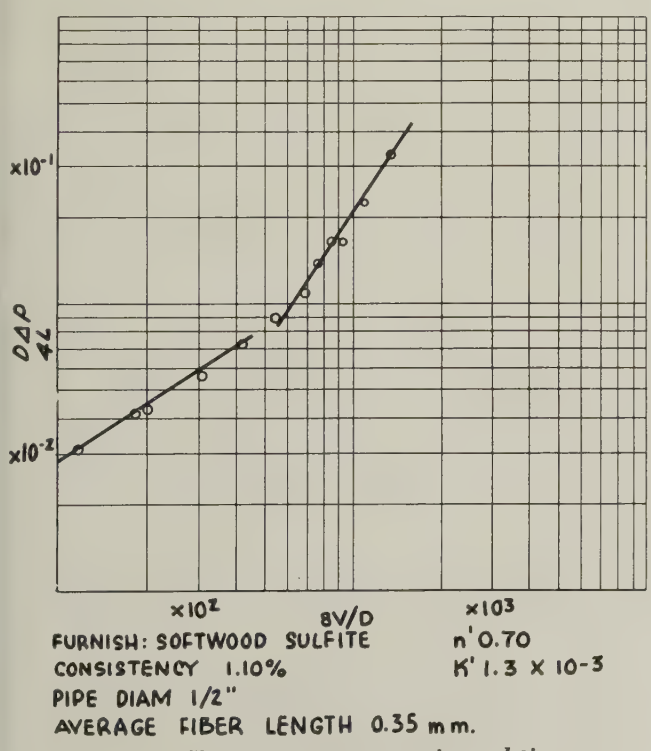


Fig. 2. Shear stress versus reciprocal time

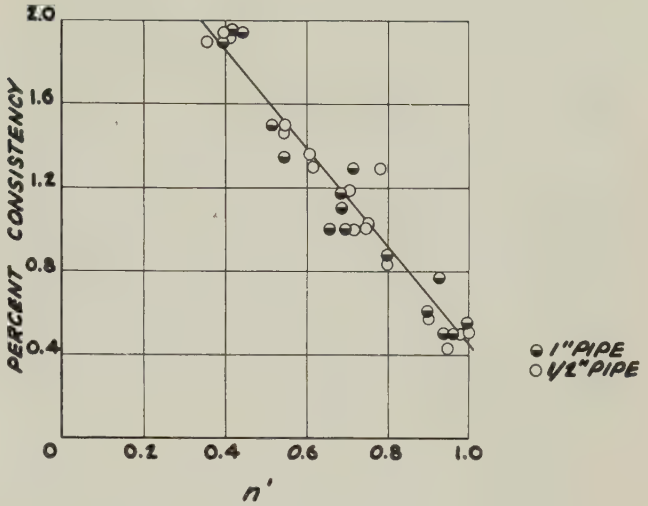


Fig. 3. Per cent consistency versus n'

particles in suspension because it was impossible to obtain meaningful viscosity values for suspensions. Recent work (*1*) has led to the derivation of a generalized Reynolds number which can be used for non-Newtonian as well as Newtonian fluids. This derivation is based on the fact that most fluids obey the relationship $D\Delta P/4L = K'(8V/D)^{n'}$ (*1*) over wide ranges of shear stress. The derivative n' represents the slope of a logarithmic plot of $D\Delta P/4L$ versus $8V/D$ and the constant K' represents the intercept of this line with the y axis.

Figure 2 is a representative plot of this equation from experimental data obtained with paper pulp slurries. This logarithmic plot represents a particular pulp at a single consistency. It can be seen that there are two distinct portions of the curve, each having a different slope. The lower portion of the curve represents the laminar flow region and the upper portion with the steep slope represents the turbulent flow region of the fluid under study. It is very important for the Reynolds number derivation which follows to obtain this slope n' and intercept K' in the laminar flow region.

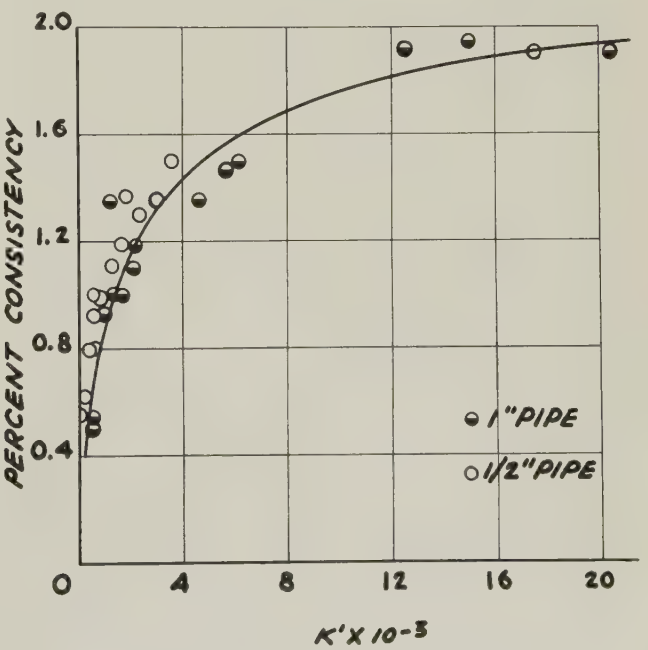


Fig. 4. Per cent consistency versus K'

Using the relationship given above, a generalized Reynolds number is defined as $N_{re} = D^{n'}V^{2-n'}\rho/\gamma(1)$ where γ is the apparent viscosity of the fluid and is defined as follows: $\gamma = gK'8^{n'-1}(1)$.

For Newtonian fluids the slope n' is always 1.0 so this expression for the Reynolds number reverts to the form $DV\rho/\mu$ with which we are familiar. For non-Newtonian fluids n' can be greater or less than 1, depending upon the properties of the fluid. For paper pulp slurries n' is always less than 1.0 in the laminar flow region. The slope n' therefore defines the degree of non-Newtonian behavior of the fluid and the intercept K' defines its consistency, the greater value of K' denoting the greater consistency.

The values of n' and K' were determined for several different paper machine furnishes sampled before and after the jordan so various fiber lengths would be obtained. At least four different consistencies were checked on each grade and pressure drop data were obtained in both $^1/_2$ and 1-in. copper tubing.

Figure 3 is a plot of n' versus per cent consistency, it shows how n' varies directly as consistency and approaches a value of 1.0 as per cent consistency approaches zero. A plot of K' versus per cent consistency is shown in Fig. 4. The similarity of this curve with the curve of apparent viscosity (γ) versus per cent consistency shown in Fig. 5 points out the relationship of K' to apparent viscosity. Figure 5 shows that apparent viscosity increases quite rapidly as consistency increases up to a value of 1.4%, after which there is a very large increase in apparent viscosity for small increases in per cent consistency. The average fiber lengths of the various furnishes used in this experiment were determined by the Kane (*3*) method. The actual fiber lengths of the various furnishes were 0.20, 0.35, 0.48, 0.57, and 0.67 mm. Fiber lengths in this order of magnitude do not seem to have a significant effect upon apparent viscosity and Fig. 5 can be used to determine apparent viscosity for pulp furnishes which fall in this range of fiber lengths.

The values of n', K', and γ were used to calculate Reynolds numbers for at least ten different flow rates at various consistencies on each of the pulp furnishes. These Reynolds numbers versus Fanning friction factor (f) are plotted in Fig. 6. The curve which is drawn through these points was taken from the literature (*2*) and is the accepted Reynolds curve for Newtonian fluids. The remarkable agreement of the experimental

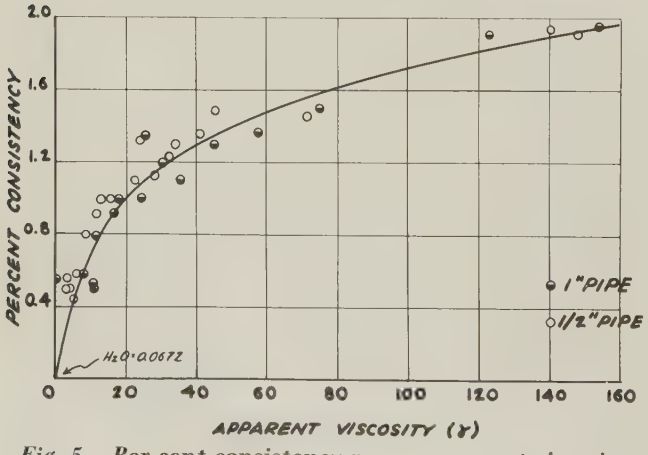
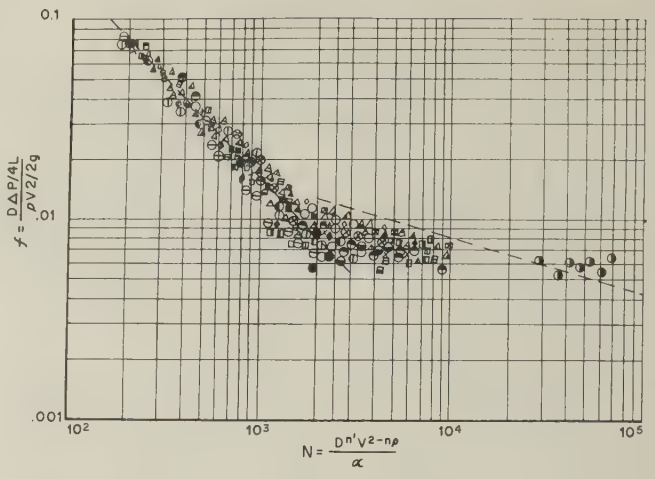


Fig. 5. Per cent consistency versus apparent viscosity



Symbol	Pulp	Pipe Diam.	Canadian Std. Freeness (CC)	% Consistency	Kane Fiber Length (mm)	K' X10^{-3}	n'	Apparent Viscosity α X10^{-3}
○	Bleached Kraft	1/2	410	1.90	0.48	17.5	0.36	148.0
◓	" "	1/2	410	1.00	0.48	0.66	0.75	12.70
◒	" "	1/2	410	0.55	0.48	0.10	1.0	3.22
◐	Bleached Sulfite	1/2	390	1.30	0.35	2.35	0.62	34.50
◍	" "	1/2	390	1.10	0.35	1.30	0.70	22.40
⊗	" "	1/2	390	0.50	0.35	0.10	1.0	3.22
■	" "	1/2	375	1.95	0.20	15.00	0.40	139.0
◨	" "	1/2	375	0.50	0.20	3.03	0.99	3.03
△	Bleached Kraft	1/2	670	1.19	0.67	1.70	0.70	29.40
◭	" "	1/2	670	1.03	0.67	0.82	0.75	15.70
◢	" "	1/2	670	0.80	0.67	0.37	0.85	8.70
◿	" "	1/2	670	0.43	0.67	0.18	0.95	5.36
◬	" "	1/2	620	1.37	0.57	1.70	0.62	25.00
◇	" "	1/2	620	0.93	0.57	0.53	0.80	11.33
◈	" "	1/2	620	0.62	0.57	0.22	0.90	5.92
◑	" "	1	410	0.55	0.48	0.14	1.0	4.50
⊖	Bleached Sulfite	1	390	1.10	0.35	2.15	0.69	36.30
□	" "	1	390	0.50	0.35	0.46	0.85	10.80
▪	" "	1	375	1.95	0.20	15.00	0.45	154.0
▬	" "	1	375	1.35	0.20	4.65	0.55	58.05
▥	" "	1	375	1.00	0.20	1.50	0.66	23.85
◧	" "	1	375	0.50	0.20	0.50	0.82	11.10
⊟	Bleached Kraft	1	670	1.90	0.67	12.5	0.43	122.0
◣	" "	1	670	1.19	0.67	1.85	0.68	30.5
◭	" "	1	670	0.80	0.67	0.44	0.86	10.5
◈	" "	1	670	0.43	0.67	0.19	0.92	5.90
△	" "	1	620	1.47	0.57	5.60	0.56	72.4
⊠	" "	1	620	1.37	0.57	1.20	0.60	24.5
✕	" "	1	620	1.00	0.57	1.20	0.73	17.9
◆	" "	1	620	0.93	0.57	0.76	0.78	15.5

Fig. 6. Fanning friction factor versus generalized Reynolds number

data with the Reynolds curve in the laminar flow region indicates that this method of calculating Reynolds numbers of pulp slurries is valid in this flow region. The onset of turbulence at a Reynolds number of about 2100, as indicated by the change in slope of the curve, is also in agreement with accepted Newtonian fluid behavior. In the transition range of Reynolds numbers between 2100 and 3300 there is an indication of a more gradual development of turbulence in pulp slurries than in Newtonian fluids as evidenced by the number of experimental points which fall below the accepted Reynolds curve. This is probably caused by the damping effect which the fibers have on the formation of small eddies so that turbulence does not generate quite so rapidly as in Newtonian fluids and tends to extend the transition range from laminar to truly turbulent flow. However, the experimental data does show that truly turbulent flow is established at Reynolds numbers of 20,000 and above and once again agree with

Newtonian fluid behavior. Further experimental work will be required to definitely determine the Reynolds curve for pulp slurries in the range of 3000 to 20,000. The important factor to be pointed out is that the calculation of Reynolds numbers in flowing pulp slurries will be much more accurate by this method than by using the conventional calculation for Newtonian fluids. This will give much better correlation between Reynolds number and observed turbulence in open channel flow. It will also allow the use of the conventional N_{re} versus f curve for determining accurate Fanning friction factors in pipe flow calculations.

This method of determining Reynolds numbers provides a tool for determining the effect of each of the various parameters; hydraulic radius, per cent consistency and fluid velocity on the intensity of turbulence observed in paper machine headboxes. It will therefore be possible to define turbulence by a Reynolds number and vary the above parameters to produce the desired intensity. It can also be used in determining optimum pipe and pump sizes for transporting pulp slurries in the consistency range of 0 to 2%.

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Presented at the Thirteenth Engineering Conference of the Technical Association of the Pulp and Paper Industry, Portland, Ore., July 28–Aug. 1, 1958.

A Critical Study of Short-Period Caustic Pulping of Wheat Straw

A. J. ERNST, T. F. CLARK, M. D. FINKNER, and H. J. DUTTON

A statistically designed and replicated experiment to study 15-min. pulping of wheat straw was carried out at caustic concentrations of 4 to 10% (basis straw) and temperatures of 100 to 180°C. Data were acquired on tests of customary handsheets as well as machine-made 9-pt. corrugating produced on a 10-in. laboratory fourdrinier machine. The complex pulping data are presented in tabular form, in topographical presentations, and in statistical evaluations.

Although commercial straw pulping antedates wood pulping in the United States, a continuous process to make straw pulp, in contrast to the continuous processes currently used to produce wood pulps, has yet to be established. This unusual situation has come about partly because of the early installation of batch-type rotary digesters for chemical pulping of wheat straw, and partly because of improvements in cook-liquor formulations and cooking techniques which, in effect, increased digester capacity. The need of the strawboard industry to replace its rotaries installed at the turn of the century has been emphasized by recent demands for greater efficiency and economy in mill practices. This need aggravated by increasing competition from wood pulps has led to a consideration of continuous pulping with its attendant advantages for the production of straw pulps for corrugating board.

Continuous pulp processes for wheat straw, in common with other continuous processes, should offer numerous advantages over current batch operations: Savings in labor charges, installation space, and "in-process" material storage facilities; maximum uniformity in pulp quality; and stabilized requirements for power, chemicals, and raw materials (*1*). Higher yields of pulp and improved quality of end products may also be anticipated as a result of research on such processes.

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The present investigation of pulping variables, temperature, and concentration of chemicals was undertaken in preparation for a pilot-plant evaluation of a continuous pulping process for straw. Approximately 15-min. cooking periods were selected because of the normally short holding-time in continuous processing equipment. Temperatures were varied over a range from 100 to 180°C. and caustic soda concentrations from 4 to 10%. Pulps produced were evaluated for yield as crude and washed; for chemical characteristics—including lignin, pentosans, permanganate number, and ash; and for physical characteristics based on tear, tensile, burst, and crush values of hand sheets and 9-pt. board prepared on a laboratory fourdrinier machine.

In view of the inherent complexity of experimental pulping data and the difficulty of their interpretation from tabular presentations, simplified methods of representation were explored. Two forms were adapted for this investigation: (1) topographic maps or contour diagrams and (2) statistical analyses.

Prior to drawing contour diagrams three-dimensional models were developed by placing wooden dowels in a rectangular peg board. The peg board simulated graph paper with the independent variables of temperature and concentration plotted at right angles to each other. Dowels were placed in the openings corresponding to the various combinations of the independent variables. The height of a dowel above a given opening was scaled to the value of the dependent variable for that combination of the independent variables. When dowels were placed for all combinations of the dependent and independent variables, the upper ends of all adjacent dowels were connected by thread to simulate a continuous surface. Appropriate values for the dependent variable were selected and the positions of these values on the various threads determined. These positions were then plotted on graph

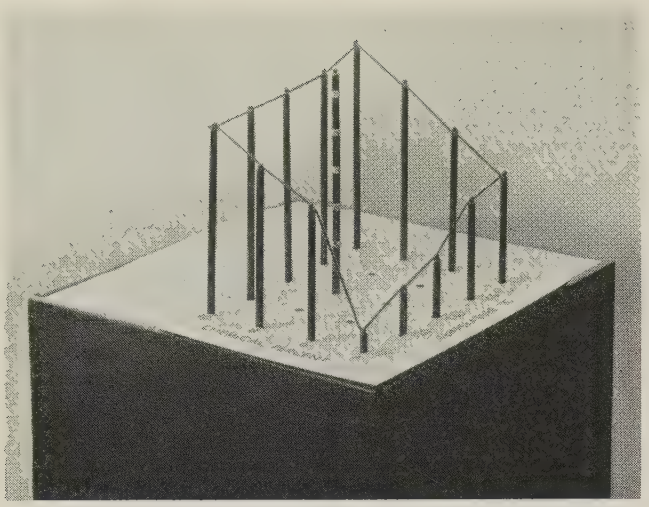


Fig. 1. Partially constructed three-dimensional model of a three-variable system showing dowels placed at some combinations of independent variables (chemical concentration and pulping temperature) and connected at their upper ends by thread. Height of dowel above peg board shows value of the particular dependent variable (e.g., yield, pentosan, tensile, Concora, etc.)

paper and adjacent points of the same value connected by lines. These are the contour lines. For ease in development and subsequent interpretation of the contour diagrams, uniform intervals between independent variables and between contour lines should be selected. A partially constructed three-dimensional model is shown in Fig. 1.

Three-dimensional models are very useful within the laboratory to simplify collation and interpretation of pulping data. In written reports or publications, photographs or isometric projections of these models very frequently become confusing because of a multiplicity of lines. The contour diagrams on the other hand are readily presented and easily understood. The efficacy of this type of presentation is demonstrated in this paper.*

In addition, data accumulated were analyzed and evaluated statistically. The experimental design consisted of a 4 × 5 factorial in randomized complete blocks with two replications. A typical analysis of variance was utilized in the evaluation of these data in an attempt to assess the influence of various temperatures and chemical concentrations on the pulping process as measured by yield, chemical characteristics, and physical properties of straw pulp. The main effects, temperatures, and chemical concentrations were tested in the analysis for mean differences which were greater than could be accounted for merely on the basis of random variability. Independence of the main effects was also determined by testing for the significance of the temperature by chemical concentration interaction. Significant differences between specific pairs of treatment means were determined by Duncans multiple range test (*2*).

Temperature treatments were selected at equally spaced 20° intervals to facilitate the use of orthogonal polynomials in linear and curvilinear regression analysis. It was possible, therefore, to test the adequacy of a linear, quadratic, or cubic polynomial for describing any trend associated with the means of the various temperatures under treatment. Conventional tables are retained for comparison. This present paper therefore constitutes not only a critical study of pulping technology, but also provides basic laboratory data upon which initial conditions in pilot-plant research on a continuous pulping process for straw may be selected.

* During the course of preparing this manuscript, an opportunity to apply topographic representation was afforded in another publication of this Division (*3*).

EXPERIMENTAL PROCEDURE

Representative sound wheat straw (Kawvale) produced in central Illinois was selected. After chopping to essentially 1 to 3-in. lengths it was carefully mixed and divided into individual batches equivalent to a digester charge. Pulping was carried out in a 10-gal. stainless-steel jacketed digester tumbling at 1 r.p.m. using a liquid-to-solids ratio of 7:1. Digester contents were brought to the specified operating temperature by direct steaming. Cooking time is considered to be the period at which the digester was held at the specified temperature and does not include the 3 to 8 min. required to elevate the digester to operating temperature or the 10 min. required to drop the digester pressure to atmospheric pressure. Pulps were removed from the digester, washed in drain bags to remove residual cook liquor, and transferred to a washer-beater to fiberize the cooked straw. The fibrous mass was then removed and pressed to approximately 20% solids content. Yields were determined on washed pulps and on fines removed in washing; beater evaluation tests were made on washed pulps according to TAPPI Standards T 200 m-45 and T 205 m-53, with the exception that the sheet weight was approximately that of 9-pt. corrugating medium.

Subsequent to beater evaluation tests, appropriate quantities of washed but unrefined pulp were refined to 600 ml. freeness (Schopper Riegler) in $1^1/_2$-lb. Niagara-type beaters. Duplicated batches of the refined pulps were combined to provide furnish for conversion to 9-pt. media on a 10-in. laboratory fourdrinier machine. Representative samples for physical testing were taken from the rolls of corrugating board produced.

RESULTS AND DISCUSSION

Effects of pulping treatments on yields, chemical characteristics, and physical properties of the straw pulps are presented by the conventional tabular method (Table I). However, the trends these data indicate are more readily visualized and explained pictorially rather than by a table; the explanation and subsequent interpretation appear under the sections dealing with contour diagrams and statistical evaluations.

Contour Diagrams

Diagrams developed for crude yield (Fig. 2a) and washed yield (Fig. 2b) have contour lines almost equally spaced and running essentially diagonal from the temperature axis to the concentration axis. For these contour diagrams the three-dimensional models have simulated top surfaces (thread network) of uniform slope with minimum values for yield at values of maximum temperature and concentration. Maximum values for yield occur at minimum values for

Table I. Summary of Cooking Conditions, Pulp Yields, Chemical Characteristics of Pulps and Physical Characteristics of Handsheets and Machine Sheets for Wheat Straw Pulps Prepared in 15-min. Cooking Periods with Caustic Soda

Cook conditions		Pulp yields		Proximate chemical analysis				Physical tests on handsheets[a]				Physical tests on machine sheets[a]						
														Tensile[c]		Tear[d]		
Chemical, %	Temp., °C.	Crude, %	Washed, %	$KMnO_4$ no.	Ash, %	Lignin, %	Pentosans, %	Burst[b]	Tensile[c]	Tear[d]	Concora	Density, g./cc.	Burst[b]	M. D.	C. D.	M. D	C. D.	Concora[e]
4	100	84.1	79.0	28.1	4.2	16.4	33.6	22	60	98	34	0.32	19	63	43	58	75	34
4	100	83.7	76.9	32.1	3.9	17.8	35.5	28	63	98	38	0.31	20	65	40	48	60	35
4	120	81.4	76.8	29.0	4.5	16.1	32.5	32	74	104	38	0.36	27	80	55	60	79	38
4	120	78.6	74.1	33.0	4.3	16.6	33.5	39	84	96	47	0.41	30	90	56	52	66	51
4	140	77.8	73.9	30.7	4.1	15.7	31.9	38	84	110	40	0.42	34	96	64	72	91	47
4	140	75.2	71.3	35.6	4.9	16.3	32.3	53	98	87	60	0.43	35	101	60	60	86	52
4	160	74.7	72.3	34.7	4.7	15.1	29.8	53	112	90	59	0.52	47	121	76	69	80	59
4	160	71.1	67.9	35.8	5.1	15.6	30.9	64	122	84	79	0.50	46	121	82	65	83	68
4	180	65.9	62.3	45.3	6.1	14.9	23.6	70	129	70	77	0.58	55	136	86	60	73	68
4	180	65.9	63.1	49.5	4.5	15.5	23.2	77	138	72	83	0.56	54	148	83	68	74	72
6	100	74.3	70.9	30.4	3.8	12.9	32.8	66	136	62	83	0.56	54	143	85	61	72	85
6	100	74.0	70.7	34.9	3.8	13.8	33.2	50	106	80	63	0.53	45	131	78	51	69	77
6	120	69.1	66.8	33.2	4.3	11.9	29.6	65	126	64	80	0.62	66	149	90	60	75	92
6	120	71.9	69.0	31.6	3.9	12.9	31.7	67	138	60	87	0.60	62	168	97	57	68	95
6	140	69.4	67.0	36.5	4.0	12.2	29.6	60	124	64	80	0.60	56	150	90	53	74	94
6	140	66.0	63.6	34.0	5.0	11.4	30.2	65	127	78	72	0.63	63	166	100	63	65	97
6	160	64.1	61.9	37.4	5.0	12.4	26.7	68	132	70	81	0.60	54	129	85	62	81	77
6	160	62.2	59.6	35.2	5.5	11.2	28.4	67	130	79	73	0.58	66	163	96	62	83	90
6	180	59.6	57.1	37.3	5.0	11.6	23.6	76	138	78	84	0.61	63	154	93	67	83	87
6	180	60.5	57.9	36.3	6.2	10.6	26.1	72	134	78	77	0.56	61	159	86	74	92	88
8	100	67.1	65.3	29.0	2.4	10.7	33.9	67	128	74	99	0.65	64	152	91	58	69	99
8	100	68.0	66.0	30.2	2.4	10.9	32.4	70	148	56	75	0.65	69	172	107	50	66	95
8	120	63.4	61.4	29.6	3.5	9.4	32.7	74	142	77	80	0.62	72	153	93	62	76	100
8	120	66.3	64.3	30.7	3.5	9.4	32.7	65	138	61	63	0.63	68	181	103	56	71	104
8	140	62.9	59.9	27.8	3.2	9.9	30.0	72	146	69	80	0.63	70	167	100	51	62	94
8	140	61.6	59.5	29.5	3.9	8.3	31.0	72	140	64	64	0.61	76	177	102	60	81	99
8	160	58.8	56.0	27.0	3.6	9.0	28.2	84	150	79	86	0.61	71	156	96	63	85	98
8	160	58.6	56.7	29.5	4.7	8.2	29.4	73	132	68	73	0.64	69	168	97	69	89	95
8	180	55.7	53.6	31.1	4.3	9.9	24.5	81	150	79	89	0.59	65	158	93	65	85	84
8	180	54.5	52.5	28.5	4.9	8.2	26.9	78	151	77	75	0.62	68	172	95	63	89	92
10	100	66.4	64.7	26.9	2.2	8.9	31.8	72	134	68	75	0.68	73	171	110	42	61	103
10	100	65.5	63.7	30.0	2.1	10.3	32.8	65	135	62	63	0.67	73	184	103	43	66	96
10	120	62.3	60.4	25.7	2.8	8.0	31.8	76	150	76	76	0.66	73	170	107	42	64	97
10	120	59.7	57.9	26.3	2.2	8.8	32.4	65	144	71	67	0.66	74	177	104	55	69	96
10	140	59.6	57.8	22.2	2.2	7.8	30.7	83	153	78	83	0.66	72	159	102	52	69	97
10	140	57.2	55.3	23.1	2.3	7.6	31.7	67	143	80	68	0.68	76	178	106	60	72	105
10	160	54.4	52.6	23.6	2.5	8.8	28.1	85	148	82	84	0.64	65	161	97	73	83	93
10	160	55.1	53.2	23.8	3.0	7.4	30.5	74	152	70	77	0.67	73	178	94	55	82	98
10	180	53.7	51.9	21.9	3.2	6.7	26.5	92	162	80	92	0.59	66	161	93	73	90	93
10	180	53.3	51.5	22.9	3.6	6.5	28.5	88	156	71	79	0.63	73	176	95	71	88	94

[a] At S. R. freeness of 600 ml. [b] Pt./ream—lb. × 100. [c] G./ream—lb. [d] G./ream—lb. × 100. [e] Concora/basis weight × 100.

temperature and concentration. These locations correspond to the upper right and lower left corners, respectively, of the contour diagrams. It is apparent that pulp yields are reduced with increasing temperature and increasing concentration of caustic soda. Since these contour lines are at an angle of 45° approximately with the axes, increasing the concentration of the pulping chemical by 2% has an effect equivalent to raising the digestion temperature essentially 20°C.

The contour diagram for ash content (Fig. 2c) shows a general trend for this characteristic to be highest at the maximum temperature; a peak is reached in the region of 6% caustic soda at 180°C. Ash content is lowest at high caustic concentration and the minimum temperature.

According to the topographic map for permanganate number (Fig. 2d), this chemical characteristic is relatively unaffected by cooking temperature at caustic concentrations above 6%, but it is greatly influenced by the concentration of the caustic soda. Below 6% caustic soda, temperature becomes the more important variable factor. Because of the causal relationship of lignin content of permanganate number, a similarity in behavior of these characteristics is anticipated. The map for lignin (Fig. 2e) shows a uniform reduction in residual

lignin when caustic concentration is increased. Little, but significant, effect is caused by temperature of pulping.

The diagram for pentosan content (Fig. 2f) differs sharply from the others in that contour lines tend to parallel the concentration axis. This fact leads to the conclusion that increasing temperature and not caustic concentration is effective in pentosan removal. The variation in pentosan content, however, is small and ranges from 27 to 33%.

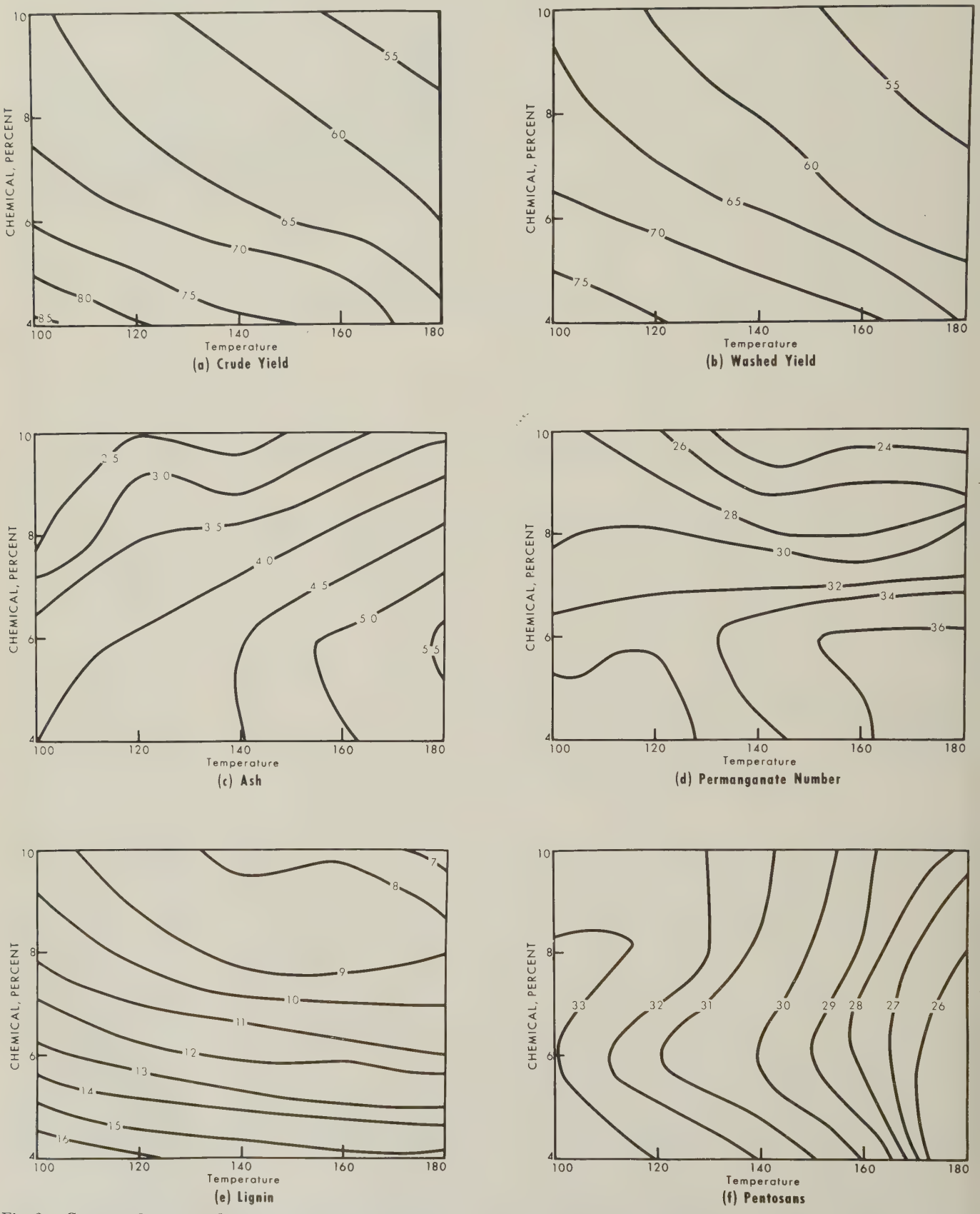


Fig. 2. Contour diagrams showing the effect of pulping variables on yield and chemical characteristics of wheat straw pulps

Topographic maps corresponding to the physical properties of the pulps were developed to depict evaluations made on handsheets from beater tests (Fig. 3) and on 9-pt. boards from machine runs (Fig. 4).

The topographic maps for burst (Fig. 3a), tensile strength (Fig. 3b), and Concora crush values (Fig. 3c) from handsheets are similar; all three show closely spaced contour lines in the region of 4 to 6% caustic that are parallel to the temperature axis. These physical strength properties, therefore, are rising sharply with increasing concentration and are little affected by temperature. Above 6% a plateau is reached or, more correctly, a very gradually rising slope reaches its highest value in the region of highest alkali concentration and highest temperature.

The topographic pattern (Fig. 3d) for tear strength as a function of chemical concentration and cooking temperature is almost the reverse of those for the other physical properties evaluated. This change might be anticipated from previous experience. Highest tear is found at the lowest alkali concentration, and the contour diagram shows that tear strength slopes downward from the 4% level to a valley in the region of 7% caustic.

Interpretations of data for physical properties of machine sheets presented in the contour diagrams are similar to those deduced from handsheet data presented in the topographic maps. Maps for burst (Fig. 4a), tensile (Fig. 4b), and Concora crush values (Fig. 4c) show closely spaced contour lines between 4 and 6% caustic, indicating rapidly increasing values for the properties of the machine sheets with the change in concentration of the pulping chemical. Above the 6% concentration a plateau or gradual increase in value of the characteristic with increase in concentration is indicated. These diagrams, however, differ from those for handsheet data. In the case of machine sheets the highest values for burst, tensile, and crush are shown in the regions of lowest temperatures and highest caustic concentration, while in the case of the handsheets these characteristics were highest in regions of highest temperatures and highest caustic concentrations. The contour pattern (Fig. 4d) for tear strength of machine sheets is similar to that of the handsheets, differing again in form from other physical properties.

Summarizing the data thus far: topographic maps for the quality characteristics of burst, tensile, and crush, which are so important to the performance of straw corrugating media, show an almost inverse relationship to the maps for yields of straw pulp. The

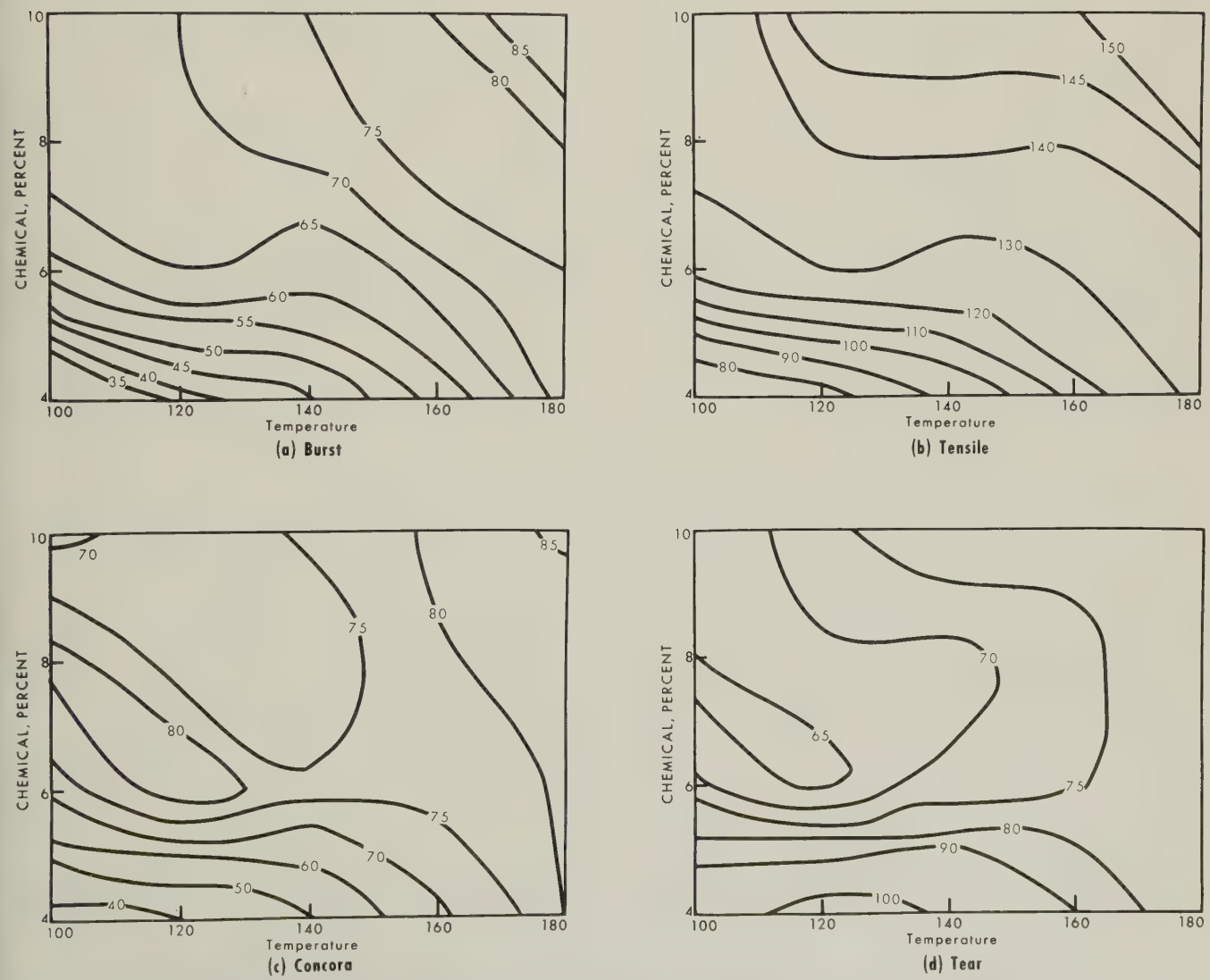


Fig. 3. Contour diagrams showing the effect of pulping variables on physical properties of handsheets from wheat straw pulps

Table II. Analysis of Variance for Chemical Analysis—Mean Squares

Source of variation	Degrees of freedom	Washed yield	Ash	Pentosans	Lignin	$KMnO_4$
Total	29	...	...	...	...	...
Replications	1	1.2	0.9[a]	10.1[a]	0.8	1.6
Chemical concentrations	2	147.0[a]	10.4[a]	4.5[a]	41.8[a]	252.4[a]
Temperature	4	154.4[a]	2.7[a]	44.2[a]	4.6[a]	1.5
Linear	(1)	623.4[a]	10.5[a]	170.7[a]	16.4[a]	...
Quadratic	(1)	...	...	6.1[a]	...	...
Chemicals × temperature	8	1.1	0.16	1.1	0.3	10.7
Error	14	1.6	0.13	0.6	0.5	2.2

[a] Significance at the 1% probability level.

highest yields are obtained at the lowest temperatures and concentrations, whereas high strength properties are realized at the highest temperatures and concentrations used. Thus it appears that the selection of conditions for the commercial production of straw corrugating board must be a compromise between yield and quality.

Applicability of the relationships reported for this short-period batchwise pulping of wheat straw to a continuous process can be determined only through further studies conducted with suitable continuous pulping equipment.

Statistical Evaluation

Increasing interest is being shown within the pulping industry on the accuracy and precision of pulp evaluation tests. The present experiments provided an opportunity to use statistical analysis and/or to ascertain the significance of papermaking tests within one laboratory.

Data resulting from the 4% caustic concentration were considered atypical and were not included in the statistical analyses. The cooks from this particular treatment were extremely rough and representative test samples were difficult to obtain. The peculiar response

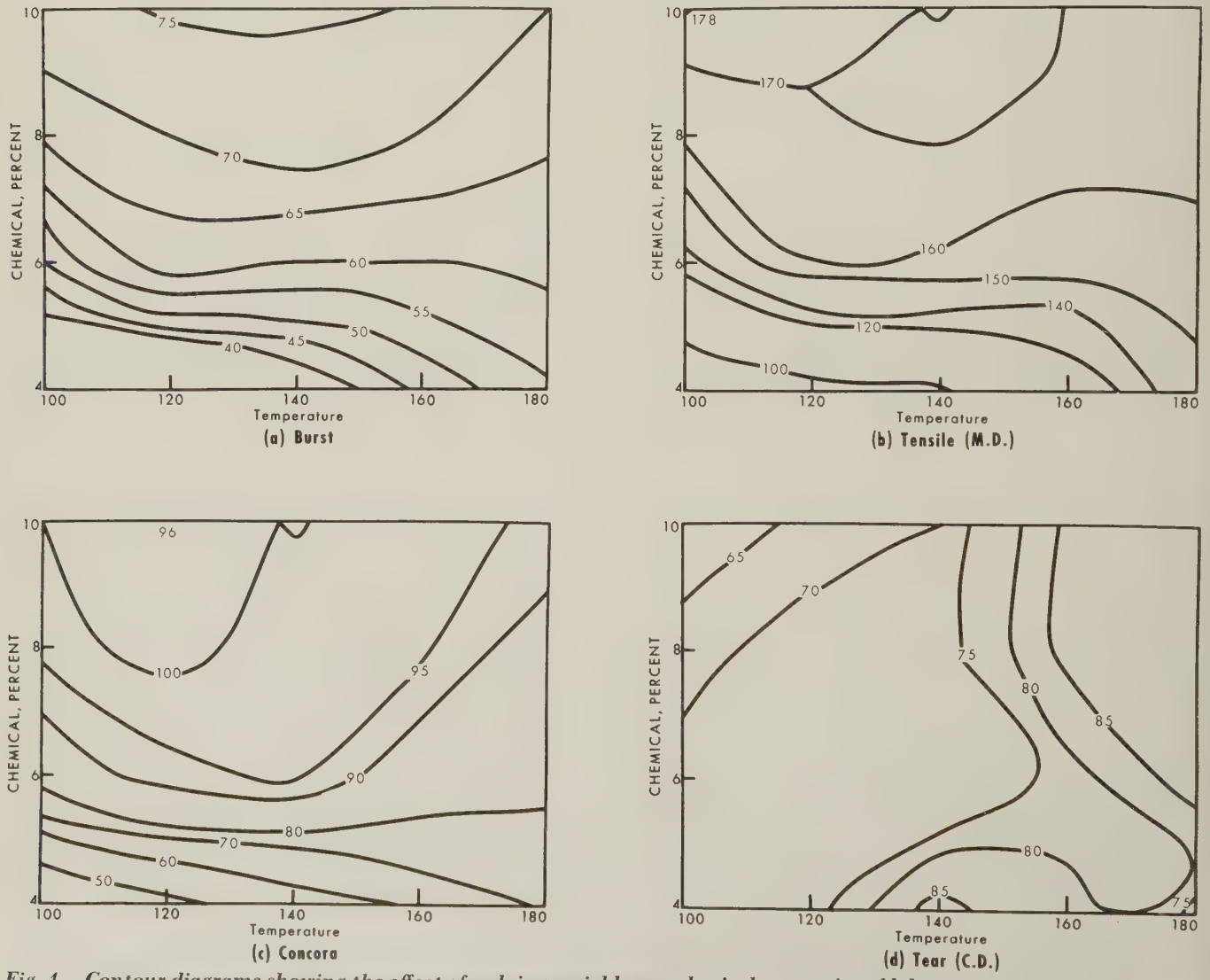
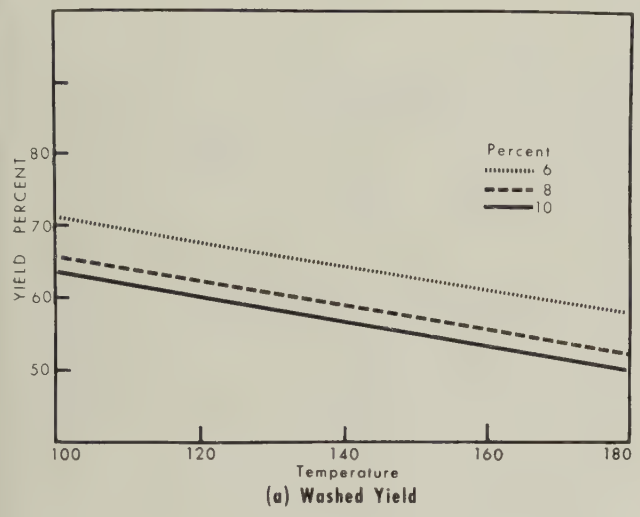


Fig. 4. Contour diagrams showing the effect of pulping variables on physical properties of laboratory machine sheets from wheat straw pulps

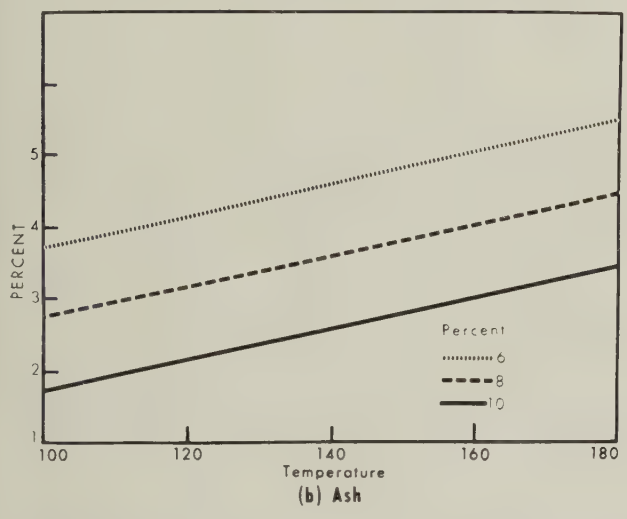
associated with the 4% concentration contributed in many cases to a temperature by chemical concentration interaction that was not present when the remaining three levels of caustic only were considered.

The analyses of variance for yield and chemical characteristics are presented in Table II. Significant sources of variation were ascertained from the mean squares in this table. For example, differences among the means of the chemical concentration treatments were significant for yield and all chemical characteristics measured. This difference was also true for the temperature means, except for the case of permanganate number. Linear regressions of yield on temperature and of each of the chemical characteristics on temperature were computed where temperature effects were significant. Linear trends were indicated in all cases. In addition, a significant quadratic trend was indicated in the case of pentosans. An interaction involving the factors of temperature and chemical concentration was evident only in the permanganate number, indicating that, except for permanganate number, these factors responded independently with respect to yield and the chemical properties measured. The effects of temperature and caustic concentration were interdependent in the case of permanganate number. These regressions are illustrated in Figs. 5a, b, c, and d.

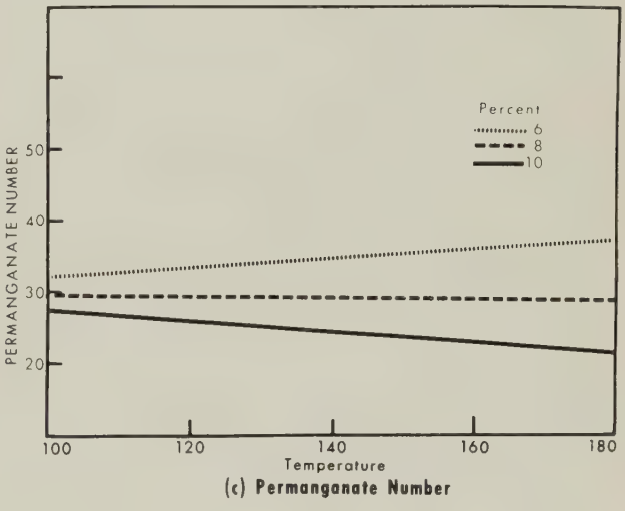
Washed yield response associated with the 6% concentration of caustic was significantly higher than for the 8 and 10%. The observed difference between these latter two treatments was not large enough to be considered real within the limits of the precision of this experiment. In other words, the difference between the observed yield from the 8% concentration and the yield



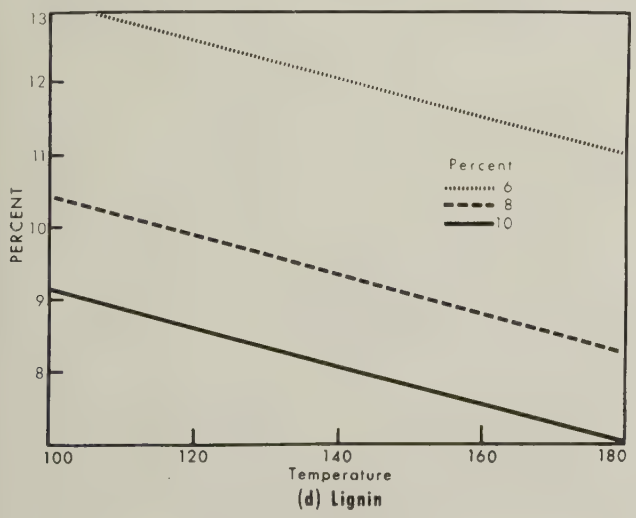
(a) Washed Yield



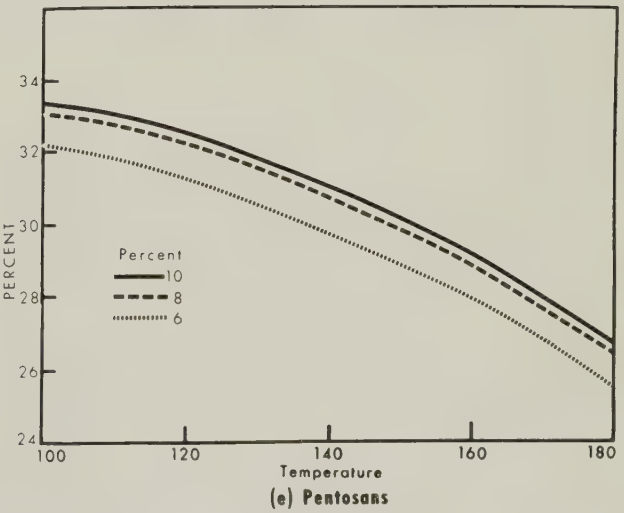
(b) Ash



(c) Permanganate Number



(d) Lignin



(e) Pentosans

Fig. 5. Regression analyses for washed yield and chemical characteristics of pulps prepared by cooking wheat straw at three concentrations of caustic soda

Table III. Analysis of Variance for Physical Tests on Handsheets—Mean Squares and Machine Sheets—Mean Squares

Source of variation	Degrees of freedom	Handsheets				Machine sheets			
		Burst	Tensile	Concora	Tear	Burst	Tensile	Concora	Tear
Total	29								
Replications	1	203[a]	61	1033[a]	68	32	1559[a]	26	32
Chemical concentrations	2	165[a]	905[a]	12	32	453[a]	1085[a]	239[a]	22
Temperature	4	227[a]	219[a]	65	110	39	77	75[b]	512[a]
Linear	(1)	874[a]	735[a]	...	432[a]	...	...	75	1750[a]
Quadratic	(1)	...	...	...	...	103[b]	...	174[a]	129
Chemical × temperature	8	12	20	73	38	25	83	36	17
Error	14	19	68	26	54	16	55	17	22

[a] Significance at the 1% probability level.
[b] Significance at the 5% probability level.

from the 10% concentration could be explained on the basis of random variability. The pentosan analysis for the 6% treatment was significantly lower than for the two higher concentrations. The observed difference between the 8 and 10% treatments was not sufficiently large to enable a statistical separation of means of these two concentrations. Each of the three levels of caustic was significantly different from one another with respect to response for lignin, ash, and permanganate number.

The results of the analysis of variance for physical properties as determined on handsheets are shown in Table III. Chemical treatments were significantly for burst and tensile strength. Temperature effects were also significant for burst and tensile; a linear trend was apparent for burst, tensile, and tear. A temperature by chemical concentration interaction was found in the case of Concora crush strength. These results are illustrated in Figs. 6a, b, c, and d. Differences among the means of the 6, 8, and 10% caustic treatments were all significant for burst. The 6% treatment was significantly lower than the 8 and 10% for tensile, whereas the latter two could not be separated statistically. None of the chemical concentration treatments were different for tear. Although the chemical treatment means were not significantly different for Concora, the trend lines were different, resulting in the temperature by chemical concentration interaction.

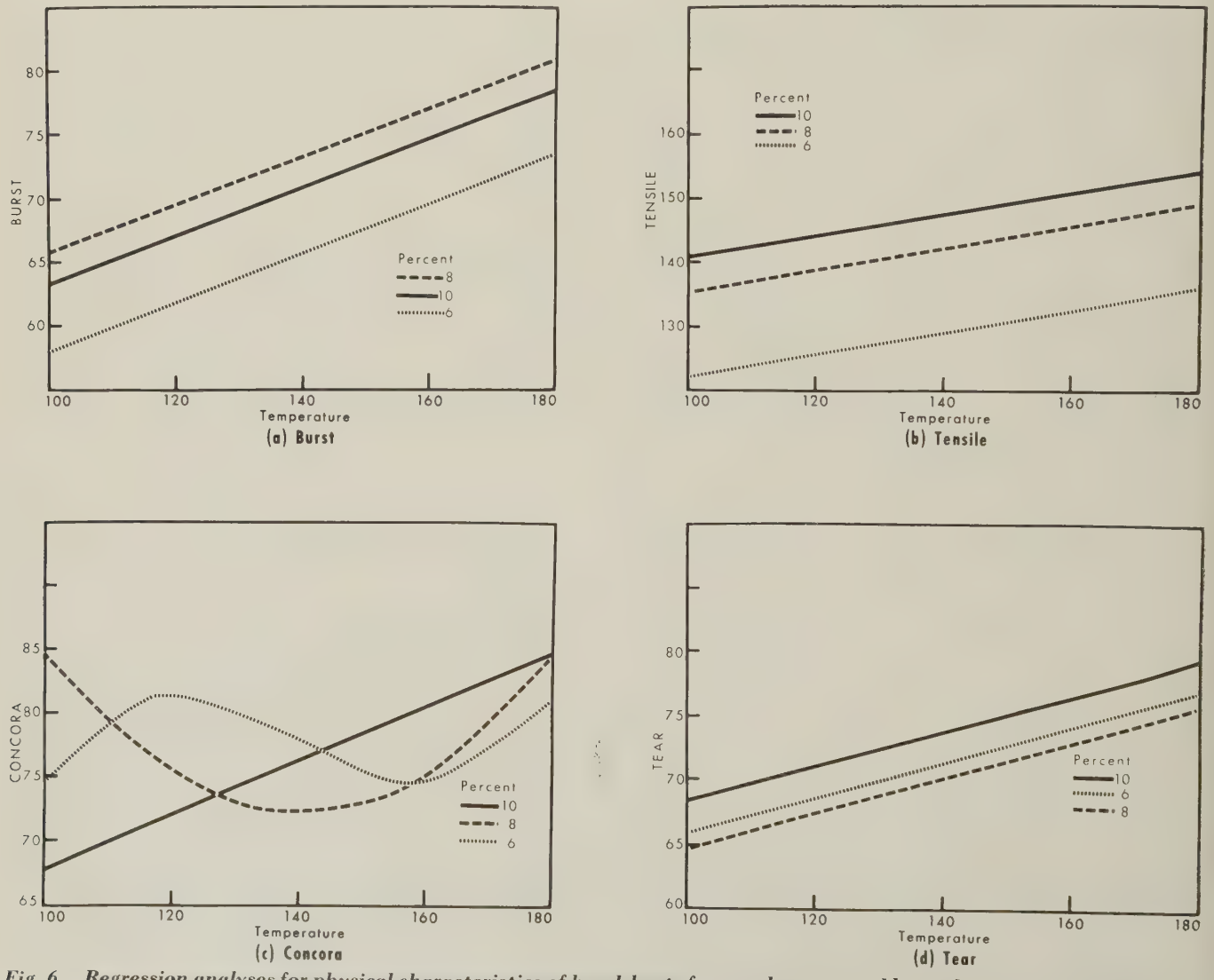


Fig. 6. Regression analyses for physical characteristics of handsheets from pulps prepared by cooking wheat straw at three concentrations of caustic soda

The results of the analysis of variance for physical properties determined on machine sheets are also shown in Table III. Significant chemical effects were indicated for burst, tensile, and Concora crush strengths. Quadratic trends were apparent for burst, Concora, and tear.

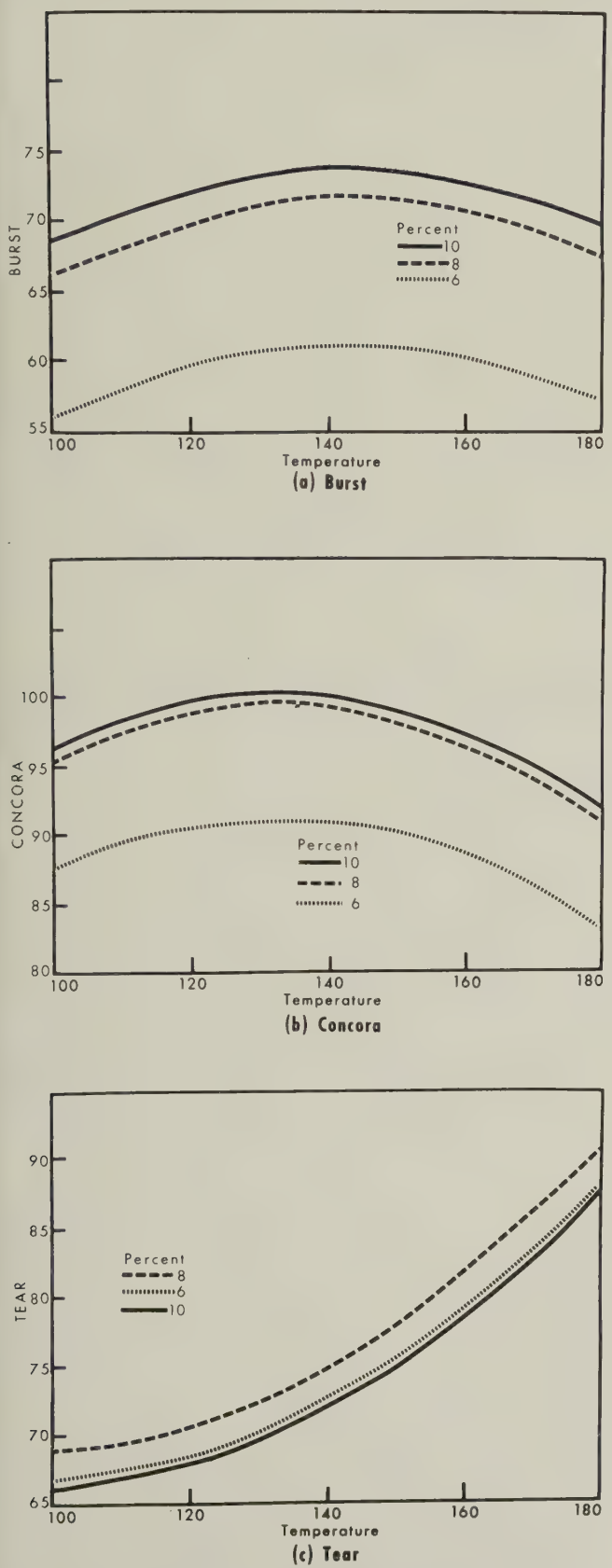


Fig. 7. Regression analyses for physical characteristics of machine sheets from pulps prepared by cooking wheat straw at three concentrations of caustic soda

None of these variables showed a temperature by chemical concentration interaction. These results are shown in Figs. 7a, b, and c. The tensile results were not plotted because no significant regression was found, indicating that the effects of the temperature treatments could be attributed to random variability. The 6% chemical treatment, however, was significantly lower than either the 8 or 10%; these two were not different. The 6% treatment was also significantly lower than the 8 or 10% for burst and Concora crush strengths. The 8 and 10% treatments could not be separated for burst and Concora, and none of the three chemical treatments could be separated for tear.

SUMMARY

The pulping of wheat straw for corrugating board was studied under conditions of short holding-time (15 min.) in preparation for a pilot-plant evaluation of a continuous pulping process. In a statistically designed and replicated pulping experiment, variations of caustic soda concentration were made between 4 and 10%, and temperature was varied between 100 and 180°C.

The complex pulping data are presented in conventional tables, contour diagrams, and statistical evaluations. While the tabular form of the reporting data has the advantage of giving exact values, the disadvantages in space requirements for presentation and the difficulties of interpretation militate against its indiscriminate use. Contour diagrams readily permit collation of a multitude of data and further allow visual interpretation of these data. Topographic maps, however, do suffer from subjective elements used in their construction. Nevertheless, when topographic maps are combined in factorially designed experiments with statistical analysis, reliable evaluation of pulping data is achieved. For example, the conclusions which are reached by using these methods in the present study:

Crude and washed yields of pulps were found to decrease uniformly with increasing pulping temperature and with increasing concentration of pulping chemical. Permanganate numbers varied inversely as the caustic concentration but were not affected greatly by pulping temperature. The physical properties of handsheets for tensile, burst, and Concora crush strengths show similar topographic behavior with caustic concentration and temperature of pulping; rapid improvement in these properties occurred between 4 and 6% caustic with relatively little influence of increasing temperature. Increments of caustic above 6% gave less dramatic improvements in these physical properties. Physical properties of board formed upon the 10 in. fourdrinier machine were, in general, similar in behavior, but differed in absolute values from properties determined for handsheets prepared in beater evaluation tests.

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A Correlation of Two Instruments for Measuring the Ply Bondage of Paperboard

K. G. CHESLEY, E. D. JONES, and R. L. TRUAX

An instrument manufactured by the American Sisalkraft Corp. and a jumbo Mullen tester were used to measure the ply bondage of cylinder board. A correlation between the results from the two instruments has been found. Sisalkraft test results have a greater per cent variation from the mean than do the results from the Mullen tester.

In the manufacture of paper on a multiple cylinder paper machine the adhesion of the plies or the ply bond strength is one of the most important and critical properties. It is also one of the most difficult to measure accurately. Two methods for measuring ply bondage of paper and paperboard have been the subject of recent articles. A. F. Blockman and W. C. Wistrand of American Cyanamid Co. studied the use of the Sisalkraft tester (*1*). The jumbo Mullen tester as a means of measuring ply bondage was the subject of an article by John F. Donahue, Jr., and H. W. Versput of Continental Can Co. (*2*). In this study the Research Division of the Crossett Co. has compared these two testing procedures.

PROCEDURE AND RESULTS

The equipment used in the Mullen ply bondage test was the same as that outlined by Donahue and Versput; i.e., a sample cutter, double-coated Scotch tape, a number of sets of disks, a short metal sleeve, and a Mullen tester. One modification was made in this equipment in order to prevent warping of the metal disks. We found that disks cut from $^1/_{16}$-in. brass sheets warped with continuous use and this warping affected

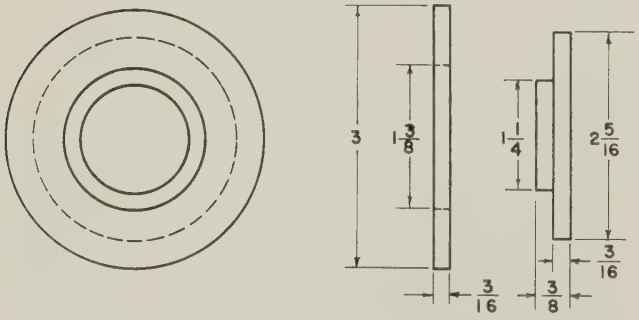

Fig. 1. Sample holding disks

the results. To eliminate this warping the annular disks were cut from $^3/_{16}$-in. stainless steel and the solid disks were made from $^3/_8$-in. brass sheets. A drawing of these is shown in Fig. 1.

The testing procedure is as follows: a strip of 3-in. 3 M tape, No 400, is placed on each side of a 3-in. wide board sample. By means of the special sample cutter samples are cut from this strip. The protective liners are removed and the sample is pressed lightly on the solid disk, then the annular disk is placed on the other side. The disks are pressed together in the sample clamp of the jumbo Mullen tsteer. With the annular disk held in place by the metal sleeve, the diaphragm of the Mullen tester is used to rupture the sample.

In the Sisalkraft test a sample 1 in. square is placed between a metal block and an aluminum angle. The block is bolted to the frame of the instrument so that a pendulum strikes the aluminum angle and splits the paper. Scotch tape with double adhesive is used to bond the sample to the metal block and the aluminum angle. The pendulum may have various weights attached to it, but throughout our tests the weight was 80 g. in all cases. The instrument is standardized so that the pointer will be at 0 when the pendulum is allowed to swing through its arc and knock the aluminum angle from rest on the metal block.

Blockman and Wikstrand proposed changing the original units of excessive angular swing to units of energy. In this work this change has not been made and the recorded unit is the excessive angular swing. Therefore, the data presented in this paper are in terms of pounds per square inch for Mullen bondage and excessive angular swing for the Sisalkraft bondage.

In preparing the annular ring samples for the Mullen test a circular sample was cut from the center. This center piece was large enough to be used for the Sisalkraft sample. Samples cut in this manner were assumed to be identical in bondage and the test results were paired for purposes of analysis. Ten different paperboards were used in this study. They were chosen so that the range covered by the test results would be the same as the normal operating range at the Crossett mill. A summary of these data is given in Table I.

Table I

	Mullen	*Sisalkraft*
No. of samples	634	634
Maximum value	230	36
Minimum value	80	3
Average value	138.8	11.9
Std. deviation	10.8 or 8% of $\bar{X}$	3.2 or 27% of $\bar{Y}$
95% C. L.	±21.2 or 15% of $\bar{X}$	6.3 or 53% of $\bar{Y}$
Correlation coefficient, 0.692		
Equation of regression, $Y = 0.1X—2$		

The data from the Mullen tester were found to have a standard deviation of 10.8 which is approximately 8% of the mean. For the Sisalkraft tester the standard deviation is 3.2 or approximately 27% of the mean. The 95% confidence interval on the Mullen test is

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138.8 ± 21.2. This variance is approximately 15% of the mean. The 95% confidence interval for the Sisalkraft test is 11.9 ± 6.3. This variance is approximately 53% of the mean. Since the confidence limits for replicate tests are given by the equation $t\sigma/\sqrt{n}$, it would take 13 tests on the Sisalkraft tester to get the same accuracy as would be given by one test on the Mullen tester. Table II shows the number of

Table II

Desired accuracy (95% C. L.)	*No. of tests required*	
	Sisalkraft	*Mullen*
±53% of mean	1	...
27	4	...
20	7	...
15	13	1
10	28	2
7.5		4
6	79	6
5	112	9

tests required by each method to give various limits of accuracy. This table shows that to reach an accuracy of ±5% would require a mean of nine Mullen tests or 112 Sisalkraft tests.

A study of these data has shown that a correlation does exist between the Mullen and Sisalkraft values. A correlation coefficient of 0.692 was found. The regression equation is

$$Y = 0.1\,X - 2$$

where Y is Sisalkraft values and X is Mullen values. The 95% confidence limits for the estimated Y using this equation is ±7.0. It will be noted that this compares favorably with the limits of ±6.3 for the actual Sisalkraft measurement. In other words, the Sisalkraft bondage can be calculated from the Mullen bondage as accurately as it can be determined on the tester.

SUMMARY AND CONCLUSIONS

This study has shown that the Mullen ply bondage tester has a 95% confidence limit for single tests which is ±15% of the average value. The Sisalkraft tester has a 95% confidence limit of ±53% of the average value. These limits include operator, instrument and paper variations. A correlation between the two instruments has been found. These results indicate that the Mullen ply bondage tester gives more reproducible results than the Sisalkraft tester.

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The Surface Reaction Method for Color Removal from Kraft Bleachery Effluents

HERBERT F. BERGER and RICHARD I. BROWN

Previous research by the National Council for Stream Improvement and by several kraft mills has shown that color can be removed successfully from combined kraft and bleach effluents by precipitation with lime. The resulting sludge, however, has been extremely difficult to dewater to a dryness suitable for reburning in the kiln. This paper describes laboratory and bench-scale pilot plant experiments in which caustic extract from a bleached kraft mill is treated by application to a precoat of hydrated lime on a rotary vacuum filter. The lime-lignin reaction takes place at the surface of the precoat, forming a film which may be continually doctored off exposing a fresh reactive surface. The lime-organic film is dry enough to be fed to the kiln along with lime mud, and color removal is in excess of 95%. A larger scale pilot plant has been set up at a southern bleached kraft mill by an interested equipment manufacturer and the process is now under evaluation by National Council and mill research personnel.

Although color, as such, is not a true stream pollutant, its presence in certain streams gives rise to complaints from the public. Such complaints are probably justified only when the color interferes with a downstream public or industrial water treatment plant. Even in these cases, the highly diluted pulp mill effluent color is similar to naturally occurring color in swampy waters, and is readily removed by the common coagulants used in water treatment.

The combined factors of increasing pressure from regulatory agencies and the growing need, in many areas of the country, for greater water conservation has led to research efforts aimed toward removal of color and re-use of solids-free effluents.

Approximately 60% of the total color discharged in the combined effluents of bleached kraft mills is dissolved in the caustic extraction stage of pulp bleaching. Greatest research effort has therefore been expended on removal of the lignin color from this effluent.

Previous research at several mills and by the National Council's Louisiana State University project has shown that color can be removed successfully from combined kraft and bleach effluents by precipitation with lime. Major shortcomings of the lime treatment are:

1. The gelatinous nature of the voluminous lime-organic sludge makes dewatering by filtration, or any other means, extremely difficult.

2. Sludge recarbonation, designed to render the lime-organic sludge more easily dewatered, resulted in severe foaming, in addition to which the sludge

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dewatering characteristics were not altered significantly by the degree of carbonation employed.

3. Re-solution of the organic fraction and dewatering of the residual mud could be accomplished, but too much white liquor was required and the resulting elutriate was too dilute for economical evaporation with the weak black liquor.

The fact that lime can be recovered using existing equipment at kraft mills makes the use of this chemical particularly appealing as a treatment, but a lime sludge must be reasonably dry before burning. To date, no satisfactory dewatering method has been developed for the calcium-organic sludge of about 5% solids, produced in this decolorizing process. In an attempt to overcome this obstacle, Council researchers proceeded to determine whether kraft bleach effluent could be decolorized by passage through a lime bed. In theory, adsorption and reaction might take place on the bed surface and dewatering would occur simultaneously by drainage through such a bed. The resulting organic surface film, it was expected, might then be scraped off, exposing a fresh reactive lime surface. The process was conceived to be similar in physical aspects to the separation of difficult solids by precoat filters employing filter aids. Exploratory laboratory runs showed good color removal through such a bed, and a lime-organic surface film formed as theorized.

Further thought led to consideration of vacuum filtration through a precoat of lime.

A laboratory device, designed to simulate this type of operation was set up and trial runs made. After numerous modifications, it was found that the most useful setup consisted of a "sawed-off" glass Buchner funnel equipped with a coarse porosity fritted glass disk hooked up to suction in series with a calibrated cylindrical separatory funnel provided for sampling. To deposit the lime bed, the funnel was inverted in a lime slurry and suction applied until a bed or desired thickness was formed. In the work reported herein,

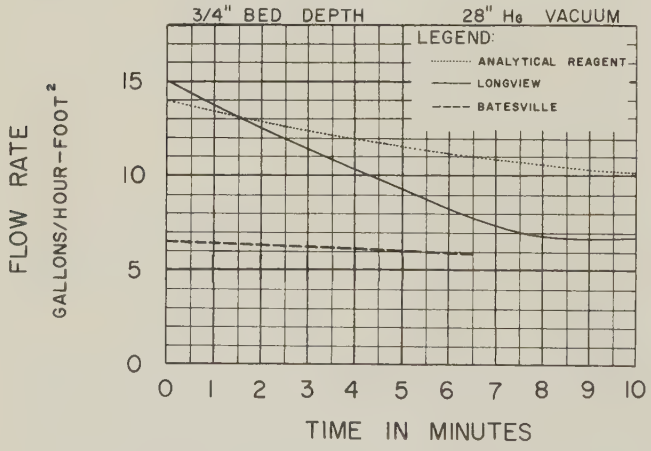

Fig. 1. Flow rate of caustic extract through lime beds

the funnel was sawed off 1/2 in. above the disk, allowing a build-up of a bed approximately 3/4 in. in thickness.

After formation and compaction of the bed, it was inverted in a reservoir of caustic extract, suction was applied, the flow rate through the bed was measured, and the effluent was analyzed for calcium oxide and color.

The chief operating difficulty of the laboratory unit was attributed to wall effects. That is, after the flow of 100 to 300 ml. through the lime bed, the waste started flowing down the sides of the bed adjacent to the glass wall of the funnel. In effect, this was short-circuiting, and color removal efficiency dropped sharply.

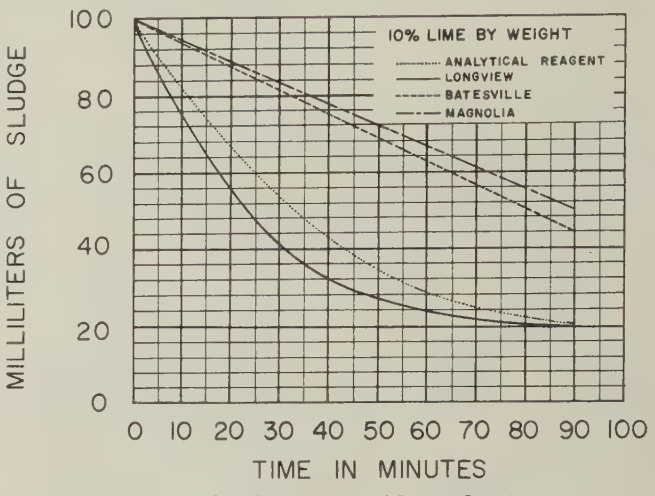

Fig. 2. Settling rates of lime slurries

Results of these preliminary investigations led to the following conclusions:

1. An essentially colorless effluent (less that 50 p.p.m.) is obtained from the treatment of caustic extracts of as high as 7800 p.p.m. color unless channeling occurs.

2. Reaction takes place at the surface of the bed in contact with the raw waste.

3. Flow rate through the lime bed is not only a function of the physical properties of the bed, but is also dependent on the quantity of color bodies allowed to remain on the surface. In short, the bed plugs. This is shown graphically in Fig. 1.

4. The curves of Fig. 1 also indicate that with a 3/4-in. bed of reagent grade hydrated lime, and 28 in. of mercury vacuum, flow rates approximated 13 to 15 gal. per hr. per sq. ft. of surface area submerged.

5. Lime loss to the effluent averaged 8 lb. per 1000 gal., approximately saturation for calcium hydroxide at room temperature.

Further laboratory studies showed that any hydrated lime with less than 20 to 25% $CaCO_3$ would remove practically all lignin color as a lime-organic film, but the commercially available hydrates varied considerably in permeability. This, of course, led to wide variations in observed flow rates, as shown in Fig. 1. Hydrated lime contaminated with calcium carbonate in excess of 25% showed high permeability, but color was not removed from the waste at the bed surface, but rather throughout its depth. Furthermore, color removal efficiency through such a bed was not as high as through the beds formed with hydrates of less than 12 to 15% $CaCO_3$.

Attempts to correlate flow rates of wastes through the lime bed with hydrated lime particle size led to inconclusive results. However, settling rate determinations made on 10% slurries indicated more rapid settling and compaction for the two hydrates showing the

highest flow rates (Fig. 2). Studies are now under way to determine whether slurry settling rate may be a useful index to precoat permeability. No further investigations into lime characteristics were undertaken at this time, since it has been established that

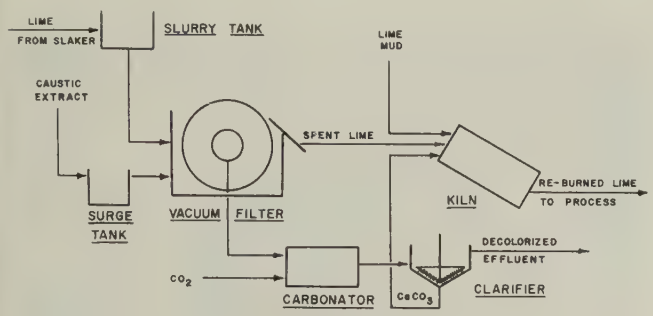

Fig. 3. Kraft bleach waste-color removal proposed process flow sheet

hydrates may be essentially "tailor-made" to specifications by control of burning and slaking.

Difficulties with the laboratory apparatus and the need for development of a method for mechanically applying the surface reaction process caused laboratory work to be set aside after the basic facts outlined above were established. It was decided that a precoat vacuum filtration unit might be suitable if a lime cake having sufficient adhesion to the filter drum could be formed and maintained intact during the doctoring operation. A proposed flow sheet for this process is shown in Fig. 3. However, before proceeding with elaborate pilot plant work, preliminary tests were performed on a 1 by 1-ft. Oliver rotary vacuum filter at the Louisiana State University Chemical Engineering Laboratory. This unit was repiped for our operation and test runs were made to determine the "bugs" in the process as well as to specify design features required in a larger pilot plant.

The test filter is shown in Figs. 4, 5, and 6. The photograph of Fig. 4 shows the filter ready for use. Figure 5 illustrates the doctor smoothing the lime precoat, and Fig. 6 is a photograph taken during the decolorizing process, showing the doctor shaving off the lime-organic surface film.

At first, considerable difficulty in building and retaining a mechanically stable lime precoat on the drum was experienced. This difficulty was overcome and it has since been shown that a stable precoat may be retained readily on a large filter of suitable design.

Caustic extract of 7500 p.p.m. color was consistently reduced to an average 50 p.p.m. Flow rates varied from 10 to 18 gal. per hr. per sq. ft. of submergence, with precoat thickness of $1/4$ in. and vacuum of 15 to 22 in. Hg. The raw caustic extract had a pH of 9.3 and a B.O.D. of 105 p.p.m., while the decolorized effluent pH was 12.0, its B.O.D. was 72 p.p.m., and lime loss was 9 lb. CaO per 1000 gal. The doctored film was 56.0% total solids, 30.0% of which was volatile. This high ash content, and visual observation, indicated that appreciable lime was removed with the lignin film, a condition characteristic of lack of control of the doctor cut on the small filter. Minimum lime requirements can be evaluated only by employing a filter equipped with a micro-doctor blade.

Carbonation of the effluent was investigated using cylinder carbon-dioxide, but in actual practice lime kiln stack gas or a submerged gas burner might be employed.

On carbonation and settling, the calcium oxide content of the filter effluent was reduced to 100 p.p.m. or 0.83 lb. per thousand gal., representing a recovery of 91% of the dissolved lime from the effluent. The pH after carbonation was 6.5 and the total alkalinity, 2030 p.p.m., consisting mainly of bicarbonates. This effluent might serve to neutralize the acid bleachery effluents on admixture with them. The treatment with carbon dioxide did not remove further organic matter from the filtrate. Settling qualities of the precipitated calcium carbonate were poor. However, it is believed that this difficulty can be rectified easily in large scale operation by applying the gas and agitating the liquid in such a manner that large crystals which settle and thicken readily are formed or precipitated on the surface of calcite crystals.

The solubility of calcium is increased in the presence of hydrogen ion, due to the carbonate-bicarbonate equilibrium shift, so we may expect an even higher

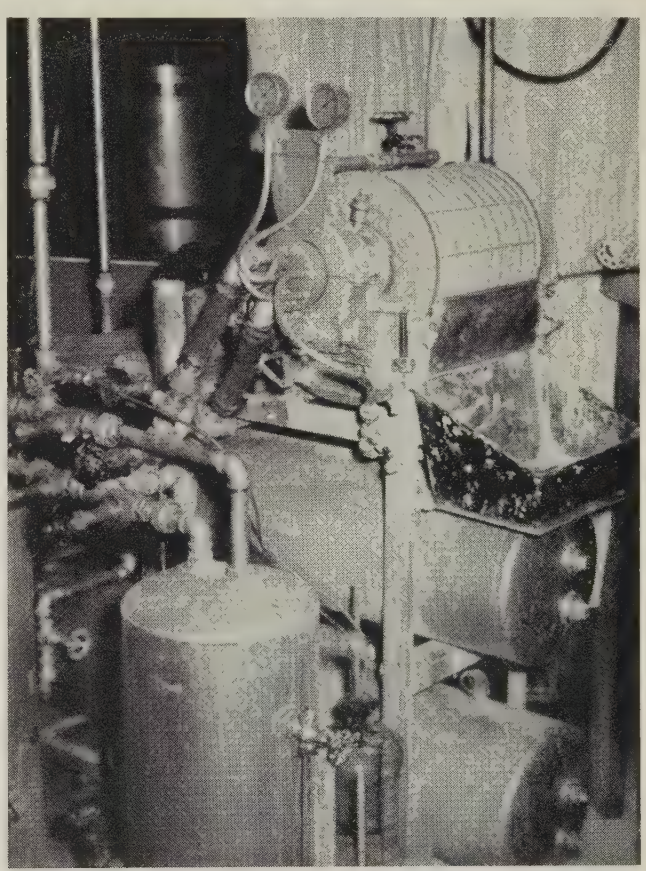

Fig. 4. Laboratory pilot filter used for color removal by surface reaction

recovery of lime if carbonation is stopped around pH 8.2.

Evaluation of presently available flow rate, particle size, and calcium hydroxide assay data leads to the conclusion that in a mill it might be necessary to employ the make-up lime for this color removal process, both because of the fact that green liquor is used to slake the lime in modern recausticizing systems and also

that such lime, even if water slaked, might be too fine and variable in character for this use. The lime requirement for the color removal process, therefore, might best be reduced to the make-up requirement if the process is to succeed economically.

Efforts to increase the flow rate through the precoat by addition of paper fiber or calcium carbonate to the lime slurry were not successful. Unbleached kraft fiber, even in small quantities, came out on the precoat surface causing the doctor to tear the bed, rather than shave the film. The addition of calcium carbonate in the form of lime mud from kraft recovery made the precoat nonadhesive to the filter cloth. The use of kraft or groundwood fines incorporated in the lime precoat may yet prove to be satisfactory as a filter aid in present studies. Another possibility to be investigated is the use of a carbonaceous precoat applied to the drum cloth before the lime. It had been suggested that such a "pre-precoat" may result in better adhesion of the lime layer as well as higher flow rates.

Encouraged by the generally favorable results obtained on the 1 by 1-ft. filter, The National Council for Stream Improvement, in cooperation with Dorr-Oliver, Inc., and East Texas Pulp and Paper Co. has set up at the Evadale, Tex., mill, a 3-ft. diam. precoat filter, equipped with a micro-doctor and other necessary appurtenances to study further the potentialities of the surface reaction method. The research engineer, co-author of this paper, is now in residence at East Texas, operating this filter to evaluate the following factors which were impossible to measure on the 1-ft. filter:

1. Maximum flow rate, including the possible use of fiber or other filter aids, or a special under precoat as suggested above.
2. Maximum drum submergence and speed of revolution.
3. Optimum cut and rate of advance of the doctor.

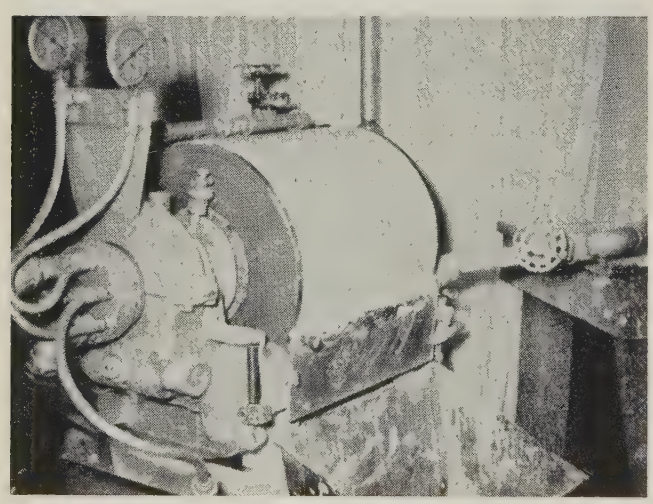

Fig. 5. Application of lime slurry for formation of precoat

4. Lime requirement, per unit volume of waste applied.
5. Minimum lime loss; investigating the possibility of hot feed to take advantage of the inverse solubility of calcium hydroxide, and perhaps increase the flow rate.
6. Carbonation and final settling requirements.
7. Capital and operating cost estimates for the process.

The almost complete removal of color and the 30% removal of the B.O.D. from caustic extract suggests an excellent possibility for re-use of this waste. Further

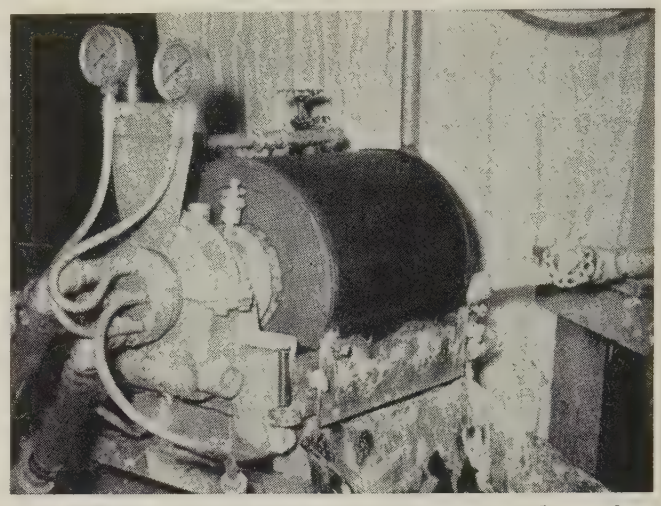

Fig. 6. Removal of color from caustic extract by surface reaction on a lime precoat, using a 1-ft. diam. rotary vacuum filter

study may demonstrate its suitability for use in the hypochlorite stages of bleaching. Should this prove possible, the water requirement in the case of three-stage bleaching would be reduced one third, or from about 18,000 (the present minimum) to 12,000 gal. per ton of pulp bleached. Such a reduction in water consumption could be the decisive factor in expansion of bleaching operations at locations where available water is now a limiting factor. A considerable saving for raw water treatment in other locations might be realized, which saving could go toward the cost of treating the caustic extract.

Another economic possibility is the recovery of lignin chloride from the film removed by the filter. Recent patents indicate that uses for this material may develop. However, experience with marketing lignin products to date indicates that, at best, probably one or two mills could supply the entire demand. Hence, this means of defraying the cost of treatment or making it a paying proposition is not a likely possibility.

It is believed that the investigations reported herein represent decided progress in the very difficult problem of kraft mill waste color reduction. Through this research, a process may be evolved whereby a satisfactory means for reducing effluent color beyond that achieved by the present efficient kraft recovery system will be available. Such being the case, it will not be a process so low in capital and operating cost that a mill could afford to apply it for purely esthetic reasons as far as the receiving water is concerned. Its application would come in locations where it was imperative to maintain receiving waters low in color for downstream municipal and industrial users or where process water is so costly or scarce that extreme measures must be taken to reduce in-plant consumption.

Presented at the Twelfth Alkaline Pulping Conference of the Technical Association of the Pulp and Paper Industry, Hot Springs, Ark., Sept. 24–26, 1958.

On a Device to Objectively Grade Letterpress Print Quality

WILLIAM H. CUFFEY and LOWELL W. ZABEL

A printability tester is described which photoelectrically grades a book paper sheet's ability to reproduce a special radial line or a parallel line letterpress print. The system counts the number of times the lines are totally or partially missing over a given area of the print. Comparisons of the objective test results and visual grading results are given.

IN LARGE measure the success of a book papermaker's efforts are judged by the fidelity with which the paper reproduces a printing plate. As one test of his success, the paper can be printed under carefully controlled standard conditions with a 120-line screen of halftone dots at a 50% tone density. The resultant letterpress prints can then be visually graded against arbitrary preselected standards by trained graders. It is desirable, when possible, to make a testing system independent of the judgment of the graders. Hence a device called a "printability tester" has been developed to objectively grade the letterpress prints.

GENERAL

The printability tester is based on the following principle: one can cause a system to count the number of total or partial "skips" in the print over a given area of the printed sample. If there are few or no skips, the print is a good one. If there are many skips, the print is a poor one. The printability tester then is simply a device to count the number of total and partial skips in a given area of the printed sample.

First, to be considered are the printing plate etches that can be used; second, how printed samples are handled in the printability tester itself; then, thirdly, the visual and the objective test systems are compared.

PRINT PATTERN

The halftone dots of the existing subjective test prints do not lend themselves to easy scanning and counting. To mechanically scan such a pattern and optically view each dot individually would be a difficult task at best. Hence it was decided to go immediately to a series of lines to make the scanning job easier. The pattern on the test plate will, of course, determine how the printed samples are to be mechanically handled for counting.

Several test patterns of lines can be used. For example the radial line print in Fig. 1 was made. The outside diameter of the print is 6 in. The plate was made from a photograph of a large annular ring which had been toroidally wound with a plastic thread. Of course the tone density of such a radial line pattern is not constant with changing radius. The advantage of such a print is that one needs no blanking of a joint in the paper. In addition, however, the plate requires that matched samples be printed for the halftone dot prints in the visual system.

Another pattern that can be used is shown in Fig. 2. This plate has a 4-in. diam. radial line pattern and also includes halftone and solid areas. This particular plate fits easily into the routine printing system and provides printed areas for both comparisons within one print.

A somewhat different test print is shown in Fig 3. This print consists of 120 parallel lines per inch at 50% tone density. The lines run in the long direction of the print. The advantage of this plate is that it permits several samples taped on cellophane to be printed simultaneously. It does, however, require blanking of the joint, as will be shown later.

Each of these plates are compromises, of course, to more or less tailor-make the objective system fit the established routine printing system.

Standards for calibration purposes are easily obtained photographically from the original negative of the pattern or by printing on a high grade book sheet. Thus one can check the entire system to get the calculated number of counts from a perfect print.

No attempt was made here to alter the routine printing pressures, inks, etc. Indeed, the test system was more or less geared to fit into the present printing routine.

THE PRINTABILITY TESTER

In Fig. 4 the radial line printability tester is shown in an early experimental stage. Above the sample holder a self-illuminating Bausch and Lomb microscope views the spinning print. This viewing system is diaphragmed to view just more than a single line width. A phototube is mounted in the housing over the microscope. The amplitude of the signal from the phototube

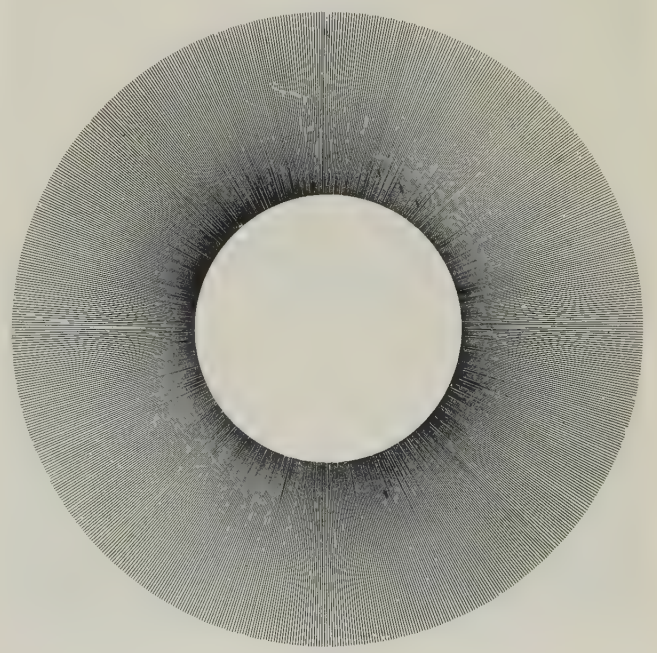

Fig. 1

WILLIAM H. CUFFEY, Physicist, Fluid Mechanics Lab., and LOWELL W. ZABEL, Chief, Instrumentation Lab., Research and Development, Kimberly-Clark Corp., Neenah, Wis.

depends on the completeness of the moving printed line being viewed. If the viewed area of the line is totally missing, then no electrical pulse results. If the line is partially formed, it may or may not be counted depending on some arbitrary preset rejection level. As is shown in Fig. 5, this signal is fed to a cathode follower, through a filter, and to a Berkeley events per unit time meter. The filter eliminates unwanted signals such as the 60 cycles per sec. ripple on the light bulb. An automatic gain control is provided to take care of changes in color of the sheet, if present, to provide a uniform contrast between the sheet and the black lines. This is accomplished by varying the amplification of the phototube to maintain the peak pulse height constant.

The counter serves both as a recorder of the accepted pulses and also as a means of precisely selecting a 10-sec. interval to view the already rotating radial line sample. This is a simple way to select an area of the sample to be viewed since it does away with any spatial starting and stopping of the sample.

With this system a perfect radial line print would count a total of (5 rev. per sec.) (10 sec.) (738 lines per rev.) or 36,900 counts. The counting rate is thus 3690 counts per sec. Subtracting the number of actual counts obtained from the number of counts for a perfect print, one gets the number of skips. We chose to plot the number of skips per second. Actually, the counter was altered to read the number of skips per second directly.

In Fig. 6 a close-up of the sample holder is shown for the radial line samples. The print is dropped into an aluminum recessed plate. A plate of glass holds the sample in place and flat. The paper rotates at 5 rev. per sec. The synchronous motor, which rotates the print, rides on a flat plate which is pivoted at one end. The other end of the plate rides on two wheels on a machined surface. The plate moves back and forth in the horizontal plane due to the heart-shaped cam on a 17 rev. per sec. nonsynchronous motor. This motion permits the system to view an annular ring on the sample as it rotates.

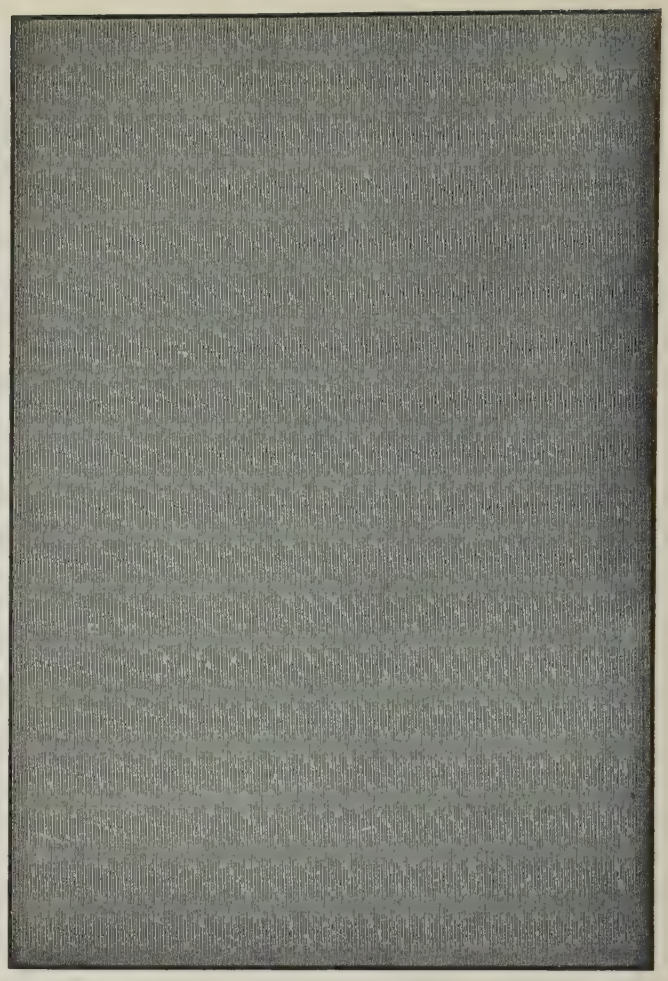

Fig. 3

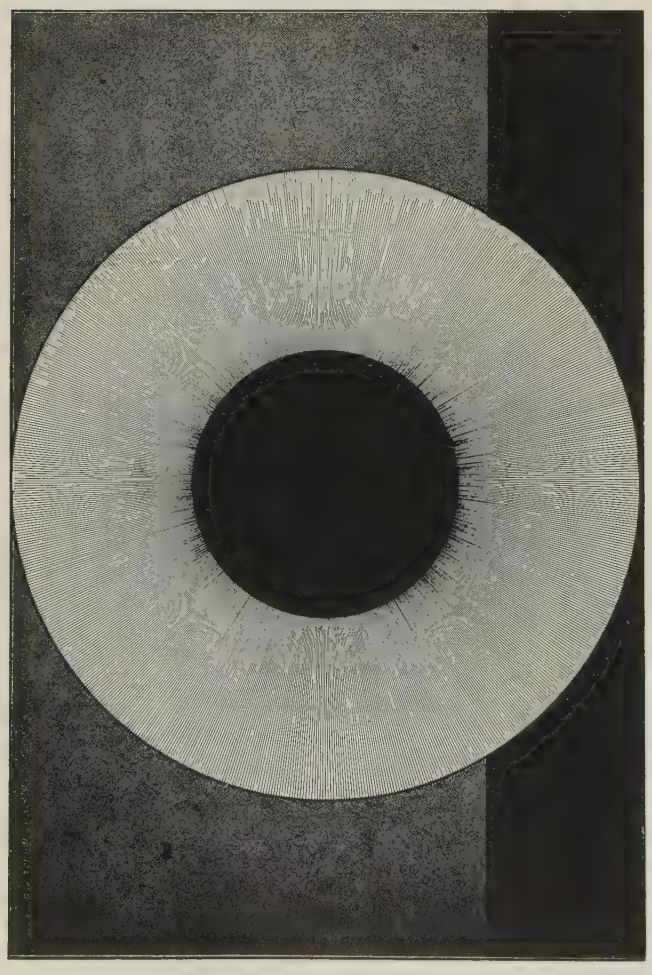

Fig. 2

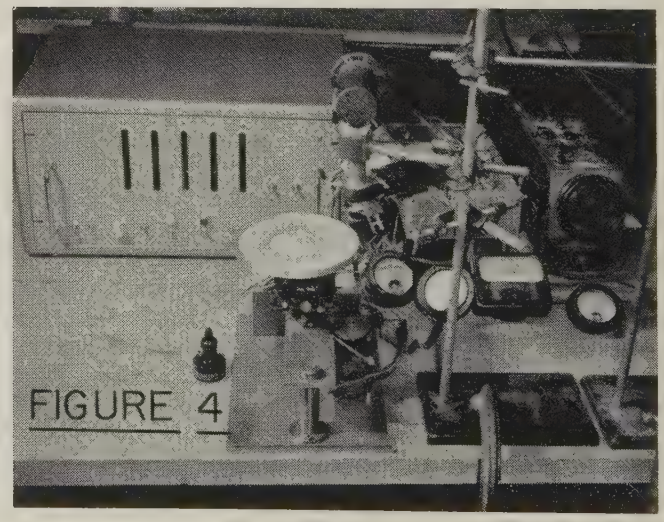

Fig. 4

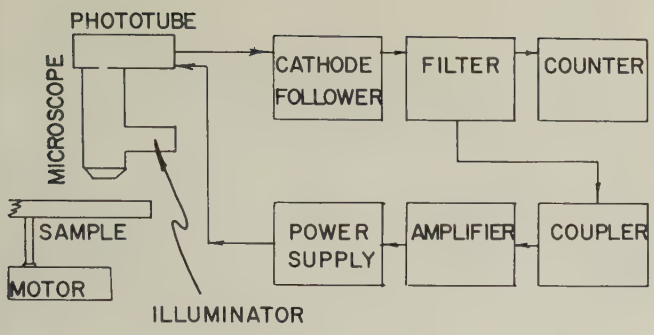

Fig. 5

The radial line system requires one print per printing impression. It is advantageous to be able to print more than one sample per printing impression. To that end the 120 parallel line per inch plate was made. With such a plate one can print five or six samples at once.

In Fig. 7 the printability tester is shown as it was built to handle the parallel line samples. The long narrow strips are mounted on a hollow roll which rotates at 5 rev. per sec. A partial vacuum in the roll holds the samples in place without clamping the ends. In this case the illuminating microscope travels across the samples in the horizontal plane along the lathe's lead screw. The signal from the phototube is handled as before. Here, one counts at the rate of (480 lines per rev.) (10 sec.) (5 rev. per sec.) or 24,000 counts in 10 sec. or 2400 counts per sec. This system works in the following manner. The drum rotation is started before the traversing of the sample begins. Then the illuminating microscope starts across the sample. The counter is automatically zeroed when the microscope views the sample. At the proper time the counter's 10-sec. interval begins. After the 10-sec. interval is completed, the total number of skips is held on the dial long enough for the operator to read and record it. The microscope system continues onto the next sample. The counter is automatically zeroed, and the 10-sec. interval begins on the next of the five samples. The number of skips remains on the dial again until the operator records them. This procedure continues across the five samples and the system shuts itself off after the fifth sample. If the operator wants to check the results, simply reverse a switch and the viewing system runs backwards over the prints again.

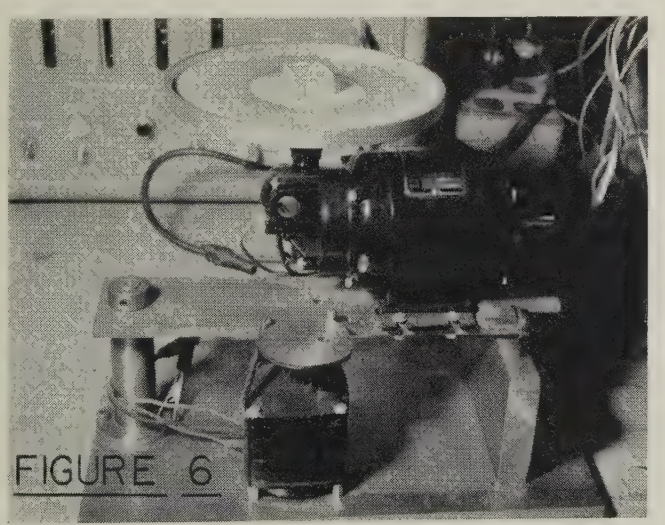

Fig. 6

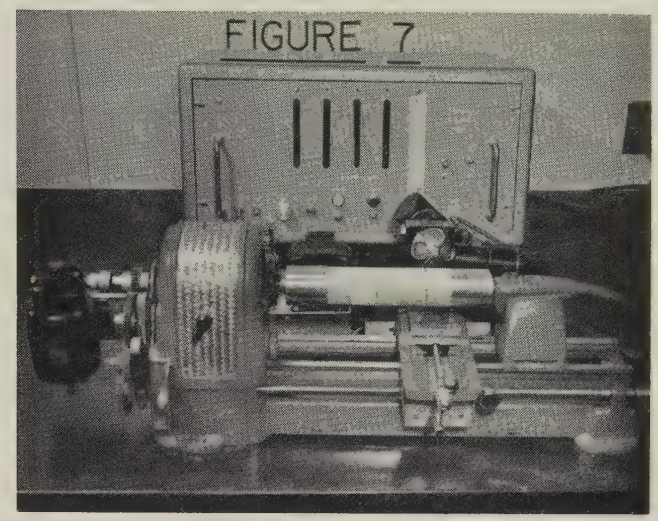

Fig. 7

Putting the strip samples on a drum usually requires some electrical blanking so that the seam or joint doesn't count. Clamping the sample with a bar can be troublesome. The vacuum in the drum did away with any clamping arrangement. In addition putting a gradual "flat" on the drum permitted the joint where the strip ends meet to go slowly out of focus, eliminating any stray signal from the seam.

PRINTABILITY TESTER AND VISUAL GRADING COMPARISONS

In order to establish that the printability tester results compare favorably with the routine visual grading using halftone dots, samples of a merchant grade paper

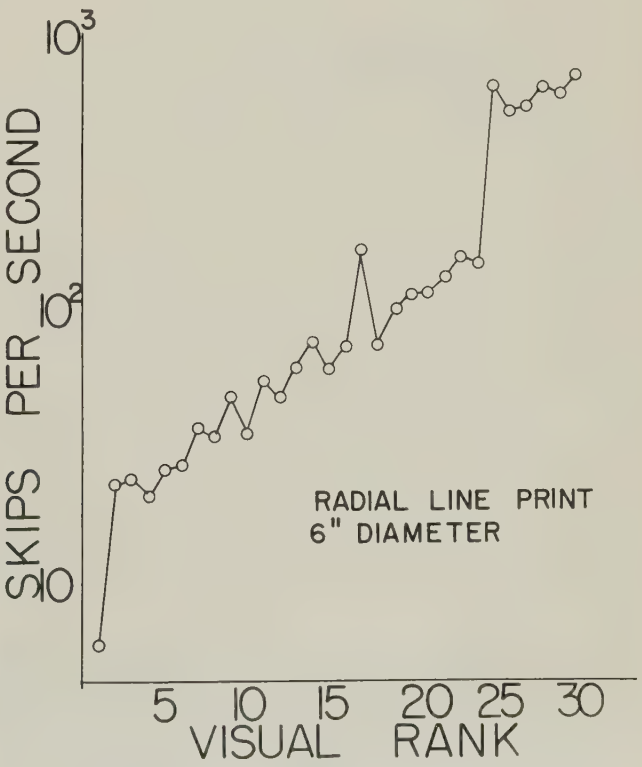

Fig. 8

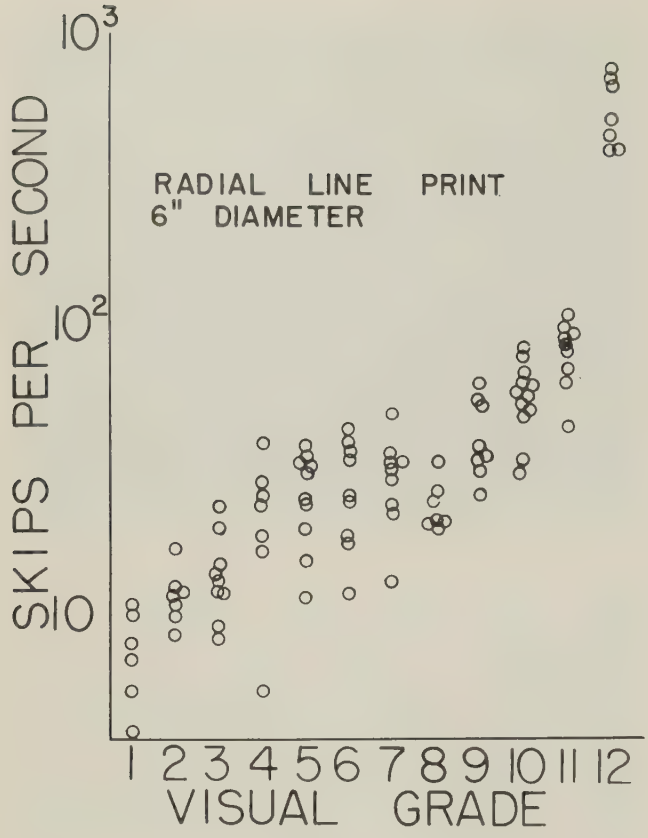

Fig. 9

were tested both ways. The visual grading could be done on matched samples or on the same print. Some of the visual grading was done on the lined samples themselves. The paper to be printed was selected from various populations known to print differently.

In Fig. 8 the number of skips per second is plotted against the visual ranking of some 30 samples. In this case the visual ranking was on the radial lined samples. Low numbers, of course, in each system mean good prints. You notice the break in the line for the last six samples. It happens that these particular sheets were

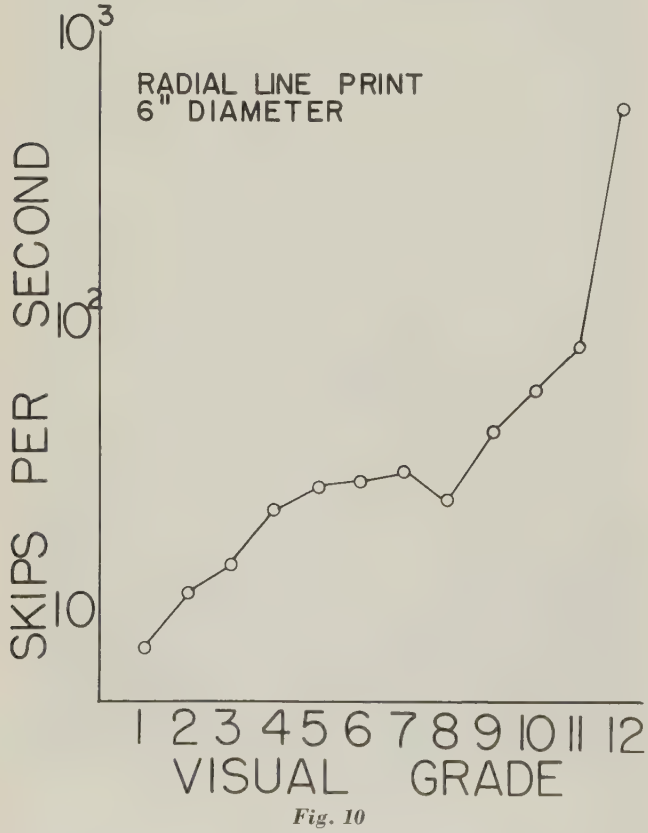

Fig. 10

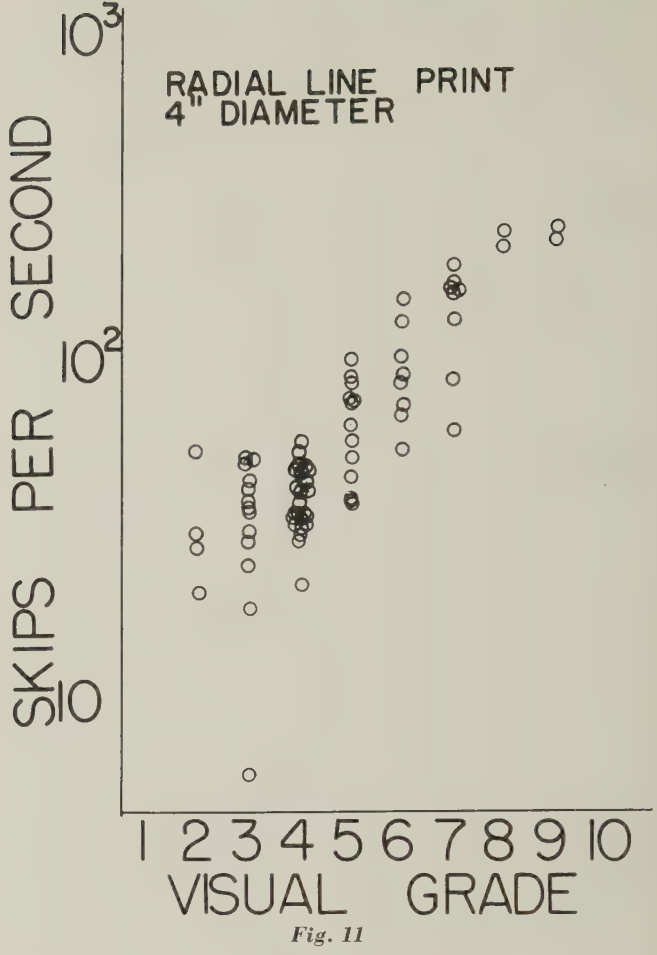

Fig. 11

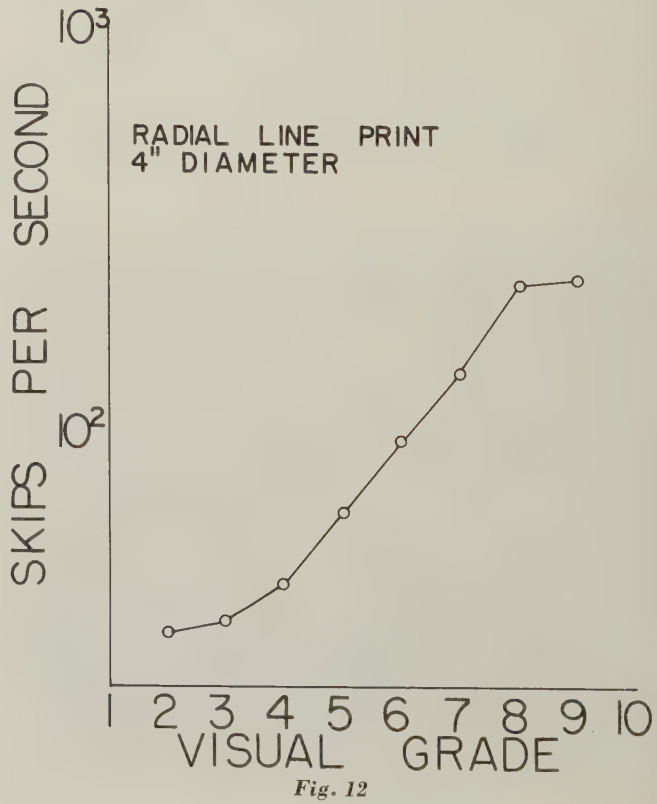

Fig. 12

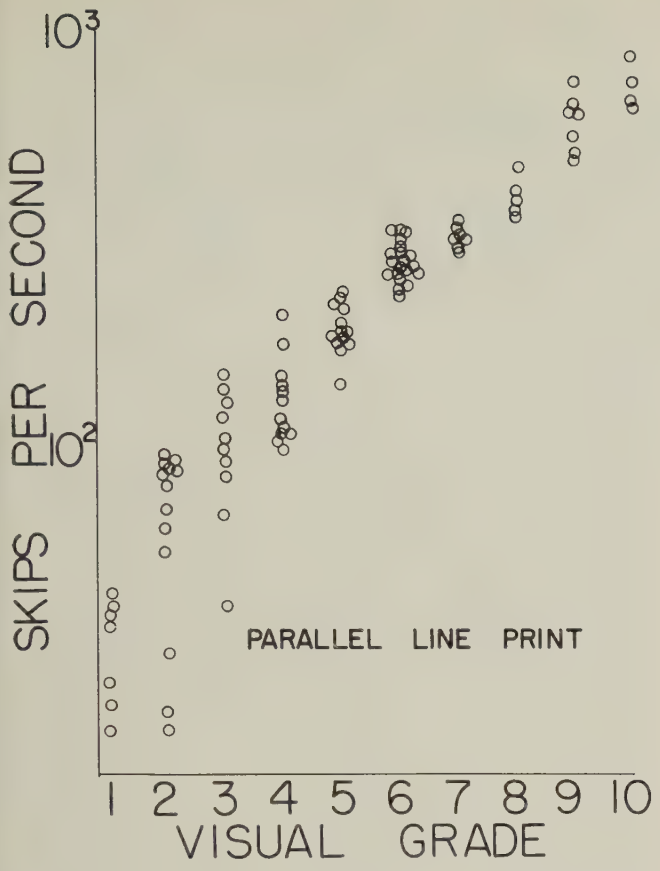

Fig. 13

of unsupered paper, which should print a good deal poorer than the supercalendered paper.

In Fig. 9 the number of skips per second using the 6-in. diam. radial line pattern is plotted versus the visual group rating. In this case the visual grader divided the samples into 12 groups. In Fig. 10 the average of the sheets in each of the 12 groups is plotted versus the group rating. It will be seen that as the sheets get visually poorer the number of measured skips increases.

Notice that for the better prints the number of skips between groups is fairly low, but that the number of skips for the poorer groups is quite high. Notice that these plots are on semilog paper.

In Fig. 11 the skips per second are plotted versus the visual grade of the halftone dots from the 4-in. diam. radial line print. In Fig. 12 the average of the printability tester skips per second are plotted versus the visual grade. It will be seen that the smaller diameter radial line pattern does much the same thing as the larger radial line pattern.

In Fig. 13 the skips per second are plotted versus the visual grading system. In this case the print was the 120 parallel lines per inch with the sample mounted on the rotating drum shown in Fig. 7. In Fig. 14 the average of the skips per second in a visual grade is plotted versus the visual grade.

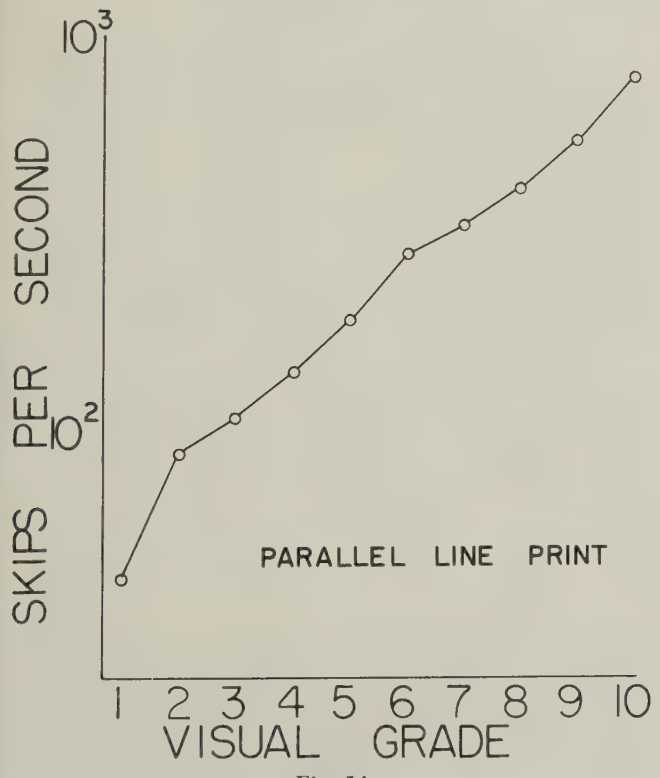

Fig. 14

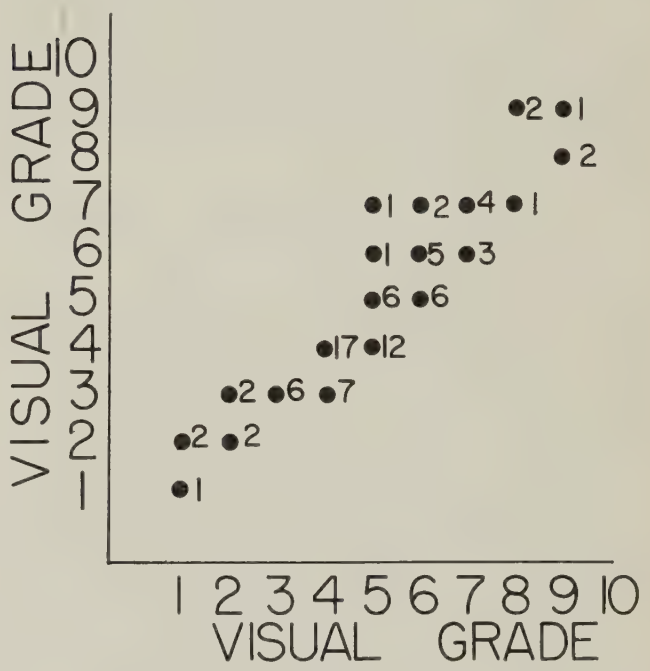

Fig. 15

There is, of course, some variability in these plots due to the visual grading itself. In Fig. 15 the visual grade of one operator is plotted versus the visual grade of another operator on identical samples. The number by each dot in the plot is the number of samples happening to fall at that coordinate point. As can be seen, a particular sample can be several grades apart as graded by the two operators.

Hence it is possible to grade objectively letterpress print quality on the printability tester using special printing patterns.

RECEIVED Sept. 15, 1958. Presented at the Ninth Testing Conference of the Technical Association of the Pulp and Paper Industry, Savannah, Ga., Sept. 30–Oct. 3, 1958.

Homer Malmstrom of Kimberly-Clark Corp. suggested the method of producing the radial line standards. Ernest Johansson of Kimberly-Clark Corp. printed and visually graded many of the samples. Miss Eleanor Thuecks of Kimberly-Clark Corp. also visually graded many samples. Herbert Tesch cooperated in making the especially designed plates at the Oshkosh Engraving Co., Oshkosh, Wis.

Alkaline Pulping—Spruce

II. The Change in Pulp Properties Throughout the Cooking Cycle

W. D. KERR and J. S. HART

This investigation of the properties of kraft pulp from spruce throughout the cooking cycle, in a range of yields from, approximately, 45 to 90%, was undertaken at the request of the Alkaline Pulping Committee of the Technical Section, CPPA. At the same time certain of the pulps obtained at different stages of the pulping cycle were subjected to degrees of selective lignin removal by means of a buffered sodium chlorite procedure in order to bring them to predetermined residual lignin values. The results for both the unbleached and bleached pulps show that the developed burst increases with decreasing yield, going through a maximum at approximately 51% yield. The values, however, are appreciably higher for the bleached pulps; with those originating from pulps having unbleached yields below approximately 70% giving exceptionally high strength values. Further investigation in explanation of these results is contemplated.

AN INTENSIVE investigation of kraft pulping was undertaken by the Pulp and Paper Research Institute of Canada immediately following World War II, at the request of the, then, Alkaline Committee of the Technical Section, CPPA. This investigation was concerned with fully cooked grades with yields between 40 and 50%. The results were published in 1948 under the title of Alkaline Pulping—Spruce (*1*) which will henceforth be referred to as part I of this series. The investigation reported herein, part II, is, again, the result of a request by a later Alkaline Committee and deals for the most part with higher yields.

The former study, together with other investigations at the Institute as well as work undertaken elsewhere throughout the world, has provided a wealth of information on the alkaline pulping of softwoods in the lower yields. However, there is a scarcity of information on the properties of kraft pulps from softwoods in the higher yields. If pulps with useful properties are practical at these yields, then this information would be of greater importance to the Canadian kraft industry. It was suggested, also, that a further delignification of selected high-yield pulps, which would be produced in this project, might result in ones with excellent properties. The delignification would be carried out by means of buffered sodium chlorite; and although this would, probably, not be an economical process, the results might warrant further study.

OBJECTIVES

The objectives of this investigation are therefore: (a) to establish the properties of unbleached kraft pulps from spruce in yields ranging from 45 to 90% and (b) to establish the properties of certain of the high-yield kraft pulps from (a) after selective lignin removal.

PLAN

In order to implement the objectives, the general plan for the investigation made use of conditions which would give a conventional kraft pulp using the 2 cu. ft. pilot scale digester, with yield variations between 45 and 90% being obtained by interrupting the cycle at intervals which would allow definition of the pulping curve on the Ross diagram (*2*). Certain of the pulps obtained at different stages of the pulping cycle were then to be subjected to degrees of selective lignin removal by means of a buffered sodium chlorite procedure in order to bring them to a predetermined residual lignin value as shown in Fig. 1. At each of the yield levels the properties were determined.

Additions to the general plan were made during the investigations. These were: (1) a short investigation of the effect on yield and quality of variations in maximum temperature and sulphide charge. This followed the procedure developed at the Institute in previous work on western cedar (*3*). (2) A comparison between the properties of a bleached pulp produced in a single-stage sodium chlorite purification and that from a conventional, multistage bleaching procedure.

METHOD

Wood

The wood used in this investigation was black spruce having the following analysis:

Chemical	
Roe No.	33.0
Lignin, %	27.4
Pentosan, %	9.4
C & B cellulose, %	60.1
Holocellulose, %	65.9
Alpha-cellulose, %	42.9
Ash, %	0.24
Sol. in 1% NaOH	15.2
Cold water, %	2.5
Hot water, %	4.2
Alcohol/benzene, %	2.2
Ether, %	1.2
Physical	
Basic density, %	3.0
Chip classification, in., less than	
1/4, %	3.0
1/4–1/2, %	24.3
1/2–3/4, %	33.8
3/4–1, %	29.1
1–1 1/4, %	8.4
+1 1/4, %	1.4

The chips were obtained through the cooperation of the Canada Paper Co. of Windsor Mills, Que., and on arrival at the Institute they were rescreened to remove fines and oversize chips which could have an unduly large effect on the results at the experimental

W. D. KERR, present address, Fraser Co. Ltd., Campbellton, N. B., and J. S. HART, Head, Chemical Pulping Div., Pulp and Paper Research Institute of Canada, Montreal, Que.

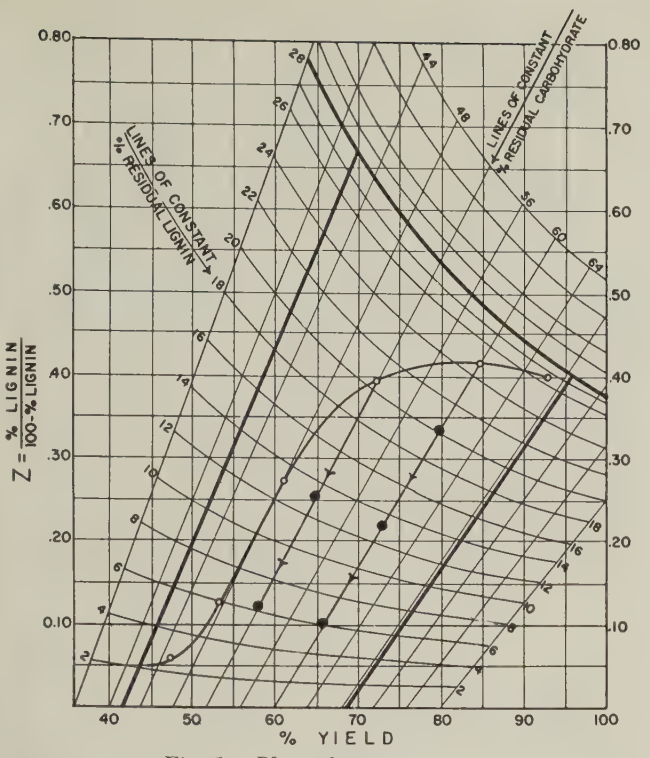

Fig. 1. Plan of investigation

scale. After screening, the chips were packed in multiwall bags, each containing one digester charge of 10 kg., and placed in cold storage at just above freezing. As the bags were being packed, twenty 500-gm. samples were taken at random for moisture determination. These gave a moisture content of 33.4% with a standard deviation of ±0.34%.

Cooking

Liquor. Cooking liquors were prepared from concentrated, decanted solutions of technical grade sodium hydroxide and sodium sulphide. Dilutions were made with water, no black liquor being used.

Cycle. The cooking cycle was made up of the conditions as listed hereunder, with variations in yield being obtained by interrupting the cycle. The very high yields were achieved before the maximum temperature was reached.

(a) Pretreatment—15 min. steaming at 100°C. and 0 p.s.i.g., followed by Va-Purge comprising two purges to 20 p.s.i.g. for 2 min. each.
(b) Charge:
Effective alkali (pH 9) = 17% on dry wood.
Na_2S (as Na_2O) = 6% on dry wood.
(c) Sulphidity = 30%.
(d) Liquor:
Ratio = 4:1 (excl. wood moisture).
Precirculation = 5 min. at 80°C. (incl. pumping time).
(e) Temperature:
Max. = 170°C. (except in those series where specified).
Cycle—the temperature was raised at the rate of 1° per min., to the maximum, or to a lower temperature in those cooks where the cycle was interrupted before the max. temp. was reached.
(f) Blow—on completion, the liquor was removed rapidly, the cover taken off and the basket and contents removed.

Pulp Treatment

Cooks having pulp yields less than, approximately, 58% were slushed from 2 to 10 min. in a Cowles Dissolver which was equipped with an 8-in. impeller. The pulps were then screened to rejection on a 0.013-in. cut flat screen. Cooks with higher yields were fiberized by one or two passes through the 12-in. laboratory Sprout-Waldron refiner. These refined pulps were not screened.

Pulp Evaluation

Yield. Screened pulp yields were determined by consistency, i.e., the screened stock was diluted to a known volume in a 400-Imp. gal. tank and, after thorough mixing, samples were taken for consistency and the weight of pulp calculated. Rejects were measured by weighing after drying.

Physical Properties. Physical properties were determined on pulp treated by the standard procedure in a Valley beater.

Chemical Properties. Chemical properties were determined on air-dried handsheets. All tests were Tech. Sec., CPPA, or TAPPI Standard methods except that alpha-cellulose and viscosity were made on samples bleached by the Yorston procedure previously described in the literature (*1*).

Selective Removal of Lignin—Chlorite Procedure

This procedure was as follows: samples of known weight and of approximately 700 g. (dry basis) were prepared and treated at 4.7% consistency and 25 to 30°C. with a 5% solution of sodium chlorite buffered to a pH of 4 with sodium acetate and acetic acid. Times were regulated by trial to reduce the pulp to a required lignin content.

DISCUSSION OF RESULTS

Unbleached Pulps—Standard Series

Composition. The plan for interrupting the cycle in order to obtain yield variations has given some interesting information on the changes in total yield with time. These are listed in Table I and are shown graphically in Fig. 2. It will be noted that, apart from the original drop to 89% yield in the first 10 min., the greatest rate of loss in yield occurs from approximately 75 to 108 min. or from 150°C. up through the 170°C. maximum. Beyond that point the yield changes very little with time.

In order to follow changes in composition with respect to liginin and carbohydrate as the yield changes, these results have been plotted on a Ross diagram at Fig. 3. The pulping area of this diagram, i.e., that bounded by the alpha-cellulose, holocellulose

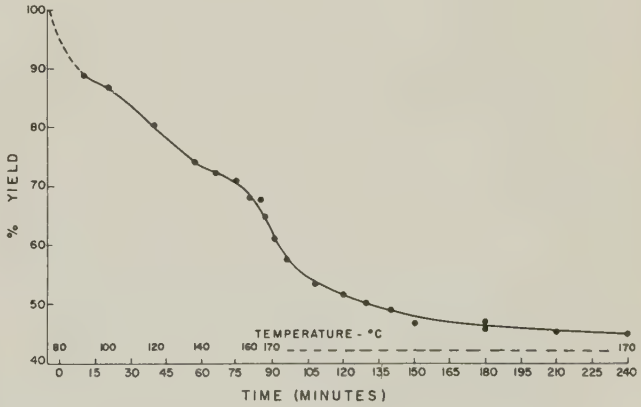

Fig. 2. Per cent yield versus cooking time

Table I. Cooking Variables and Pulp Properties (Unbleached)

Cook no.	Cook: Time, min.	Cook: Blow temp., °C.	Pulp treatment: Refiner pass	Pulp treatment: Plate sepn., 0.001 in.	Pulp treatment: Cowles, min.	Yield: Total, %	Yield: Rej., %	TAPPI Roe, no.	TAPPI lignin, %	Chemical properties of pulp: Pentosan, %	Chemical properties of pulp: Sulphur, % In pulp	Chemical properties of pulp: Sulphur, % In lignin	(Bleached) In pulp	(Bleached) CED vis.	Physical properties of pulp (at 300 freeness): Time, min.	Bulk, cc./g.	Burst factor	Tear factor	Breaking length, m.	Stretch, %	M.I.T. folds
879	10	90	2	30.6	...	88.9	...	34.0	27.1	9.3	0.24	0.89	84.1	..	97	1.96	15	0.45	4,300	1.3	4
868	20	100	2	40.6	...	86.8	...	35.1	27.5	8.4	0.24	0.87	79.4	..	100	1.96	21	0.47	5,100	1.7	7
869	40	120	2	20.8	...	80.4	...	36.2	28.4	8.5	0.25	0.88	78.8	..	115	1.72	41	0.58	8,200	2.5	84
871	57½	137½	1	6	...	73.8	...	35.1	27.6	9.5	0.27	0.98	77.4	..	122	1.54	54	0.66	9,400	2.7	315
880	66¼	146¼	1	6	...	72.3	...	31.4	26.9	9.7	0.31	1.15	78.5	..	...	...	...	...	...	...	...
866	75	155	1	5	...	70.9	...	32.6	25.5	8.7	..	..	80.6	..	134	1.50	68	0.70	11,000	3.0	440
889	80¼	160¼	1	6	...	68.0	...	30.2	23.2	8.5	..	..	79.0	..	...	...	...	...	...	...	...
867	85½	165	1	6	...	67.8	...	28.7	22.3	8.9	..	..	83.4	..	128	1.44	83	0.71	12,800	3.1	680
890	87¼	167¼	1	6	...	64.6	...	26.4	20.4	8.1	0.32	1.57	82.0	..	...	...	...	...	...	...	...
874	91	170	1	6	...	61.2	...	24.1	19.4	8.6	0.41	2.11	83.7	..	141	1.38	93	0.76	13,600	3.3	1160
865	96	170	...	...	10	57.7	4.3	22.7	17.4	7.8	..	..	87.2	63.9	126	1.34	100	0.82	14,300	3.6	1170
873	108	170	...	...	5	53.4	1.0	16.2	13.3	8.4	..	..	86.4	48.0	112	1.31	111	0.85	14,700	3.4	1670
864	120	170	...	...	3	51.8	0.5	13.8	10.1	7.9	..	..	87.4	46.6	86	1.34	112	0.91	15,400	3.6	1830
887	130	170	...	...	3	50.5	0.3	10.0	7.8	8.0	..	..	86.8	41.1	84	1.30	114	0.95	15,100	3.3	2100
892	140	170	...	...	3	48.9	0.2	7.2	5.7	..	0.35	6.14	86.8	36.3	74	1.27	112	0.97	15,700	3.3	1820
847	150	170	...	...	3	46.7	0.2	6.2	5.5	7.8	..	..	87.5	35.3	69	1.26	102	0.95	15,800	3.6	2070
842	180	170	...	...	3	45.8	0.1	4.4	4.0	7.6	0.24	6.01	88.2	29.0	60	1.28	104	0.98	15,600	3.7	1770
843	180	170	...	...	3	46.7	0.1	4.6	4.3	8.1	..	..	88.1	32.3	71	1.27	109	0.97	15,600	3.3	1950
845	210	170	...	...	2	45.1	0.1	3.8	3.6	7.9	..	..	88.2	26.2	61	1.29	104	0.99	16,100	3.3	2400
886	240	170	...	...	2	44.7	0.1	3.3	2.9	8.0	..	..	86.8	20.7	58	1.30	109	1.08	14,300	3.1	2100

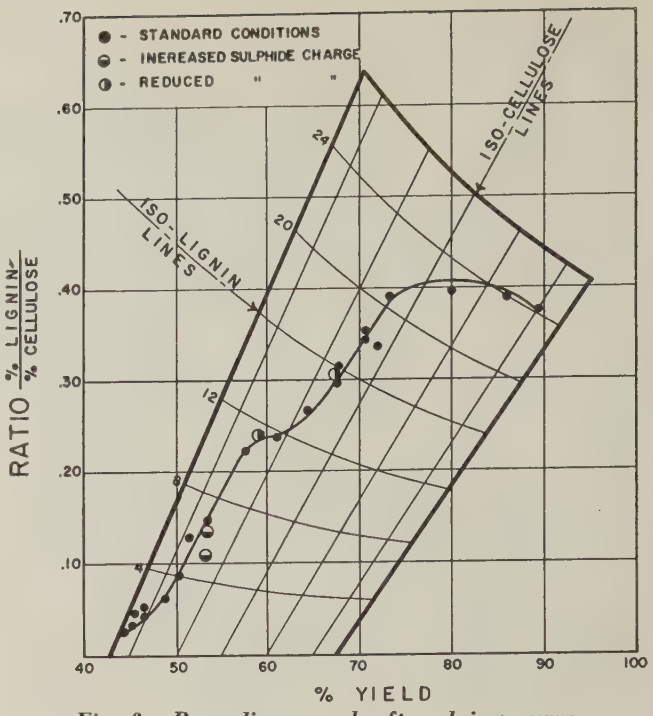

Fig. 3. Ross diagram—kraft pulping curve

and lignin lines, has been delineated from the chemical analyses of the spruce used in this study. An analysis of this diagram shows that the loss of wood substance, or loss in yield, takes place in five, more or less distinct stages as follows:

1. Down to 75% yield the loss was carbohydrate for the most part. This has also been found by Yllner *et al.* with pine (*4*).
2. From 75% down to 65% yield the loss is almost all lignin.
3. From 65 to 57% yield, carbohydrate and lignin were removed in approximately equal proportions.
4. From 57% down to 50% yield, the loss was, again, almost entirely one of lignin.
5. Below 50% yield both lignin and carbohydrate were removed.

Thus it is observed that during at least two periods in a regular kraft cycle, there are conditions that give rise to a selective removal of lignin. Some further study of these conditions may be helpful in improving the pulping process.

Another interesting feature of the composition of the residue is shown in Fig. 4. Here the pentosan content with relation to total carbohydrate in the pulp is shown on a Ross diagram. A comparison of this curve with the pulping curve in Fig. 3 would indicate that where lignin is being removed, any carbohydrate which accompanies it is predominantly pentosan.

Sulphur values for certain selected pulps are given in Table I. When it is assumed that the sulphur is bound only to the lignin, then it may be seen that for yields down to 75%, the lignin contains only about 1% sulphur. This increases to 2% at 60% yield and increases rapidly to 6% at 50% yield. This agrees with results reported by Enkvist (*5*). It also points up that at high yields, a high sulphidity may not be necessary.

Properties. Chemical: The pulp properties are listed in Table I. No viscosities were determined on pulps having yields in excess of 60% since the pulps were insoluble in the CED reagent. Below

Table II. Yields and Pulp Quality—At Two Maximum Temperatures

Cook no.	Max. temperature °C.	Max. temperature Time at, min.	Yield Total, %	Yield Rejects, %	Chemical properties of pulp Roe no.	Chemical properties of pulp TAPPI lignin, %	Chemical properties of pulp Pentosan, %	Physical properties of pulp (at 300 freeness) Time, min.	Bulk, cc./g.	Burst factor	Tear factor	Breaking length, m.	Stretch, %	M.I.T. folds
918	165 1/2	14 1/4	58.5	6.2	22.0	17.3	8.0	131	1.40	96	0.74	14,100	3.6	1220
919	165 1/2	31 1/4	55.3	1.7	16.9	13.3	8.0	115	1.38	104	0.86	14,500	3.7	1340
929	165 1/2	78 1/2	51.0	0.2	7.8	6.7	7.8	85	1.28	118	0.90	15,400	4.7	2280
974	165 1/2	183	46.3	0.1	4.0	3.4	7.7	64	1.28	102	0.92	15,000	3.7	2540
932	155	16	66.5	...	27.8	21.8	8.4	129	1.41	78	0.65	11,800	3.0	1050
978	155	54 1/2	58.8	6.5	20.3	16.9	8.3	163	1.40	100	0.75	12,300	3.2	1670
930	155	149	53.1	0.3	11.4	9.3	8.2	111	1.34	108	0.84	14,800	3.1	1580
976	155	218	50.9	0.1	8.4	6.9	9.2	89	1.27	112	0.85	14,000	3.2	2360
975	155	465	46.6	0.0	3.5	3.7	8.3	72	1.30	108	0.94	14,600	3.0	2280

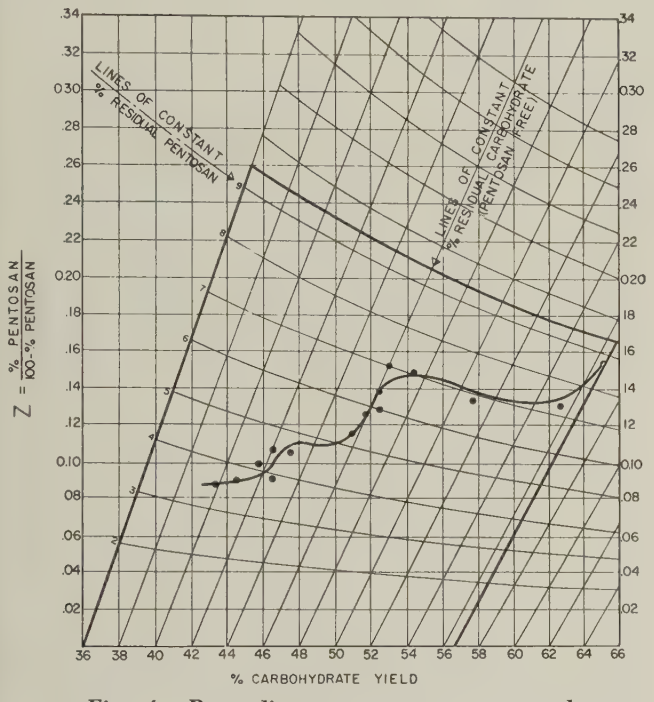
LINES OF CONSTANT % RESIDUAL PENTOSAN
LINES OF CONSTANT % RESIDUAL CARBOHYDRATE (PENTOSAN FREE)
Z = % PENTOSAN / 100-% PENTOSAN
% CARBOHYDRATE YIELD

Fig. 4. Ross diagram—pentosan removal

60% yield, the viscosity decreased with the yield as would be expected.

Another result is the remarkably good agreement between the per cent lignin and the Roe chlorine number. The relationship is essentially linear over the complete yield range as shown in Fig. 5. The calculated equation giving the regression of chlorine number on lignin content is:

$$\text{Chlorine number} = -0.370 + 1.28 \times \text{lignin}$$

This compares favorably with the equation derived by Borlew and Keller (*6*) in which they give

$$\text{Chlorine number} = -0.185 + 1.229 \times \text{lignin}$$

An equation of, perhaps, more practical use is the regression of lignin on chlorine number which for this work is:

$$\text{Lignin} = 0.350 + 0.778 \times \text{Roe number}$$

Physical: The physical properties of the pulp are listed in Table I and it will be noted that although the time to develop 300 freeness rose from 58 min. at 45% yield to 141 min. at 61% yield, it then decreased with increasing yield; at 89% yield requiring only 97 min. However the higher yield pulps were fiberized in a disk refiner and unquestionably this treatment had some effect on the subsequent beating. Nevertheless other factors, such as hemicellulose content, may have been contributory causes.

The lowest yield, of approximately 45%, gave a developed burst factor of 109. This rose slightly to 114 at 50.5% yield and then decreased with increasing yield. The tear decreased slowly with increasing yield as did the tensile strength. However with the latter there was one exception, i.e., cook no. 886 which was held for 30 min. longer at temperature than cook no. 845. There was little difference in the yields of the two cooks, but the one having the longer time, no. 886, showed a decrease of nearly 2000 m. in the breaking length. The following table gives interpolated values for burst, tear, and breaking length.

Total yield, %	Strength at 300 freeness Burst factor	Tear factor	Breaking length
45	109	1.03	16,000
50	115	0.96	15,300
60	100	0.80	14,000
70	73	0.70	11,600
80	43	0.60	8,000
90	12	0.40	3,500

A general observation on the physical properties of these pulps is that unbleached pulps up to approximately 60% yield can be made and still maintain good strength properties. Beyond that yield the strengths fall off. These pulps were produced with a constant alkali charge, i.e., 17% effective alkali. Limerick (*7*) has shown that for yields above 60%, the alkali charge may be reduced considerably, without adversely affecting pulp quality.

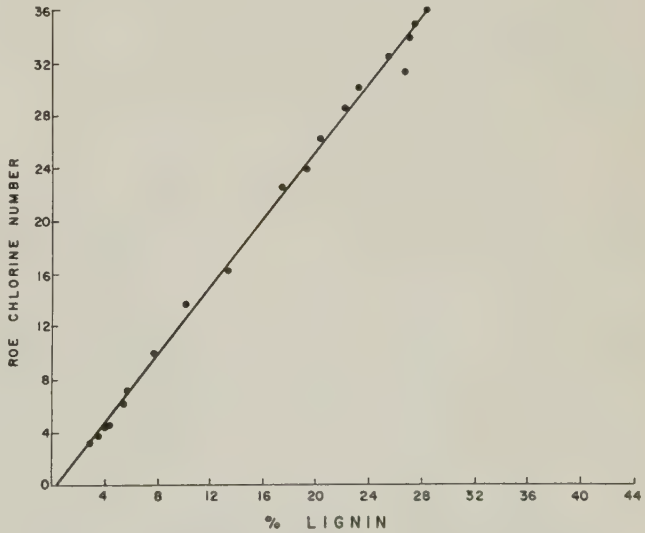

Fig. 5. Roe chlorine number versus TAPPI lignin

Table III. Yields and Pulp Quality—Comparative Cooks on Three Spruce Samples

Cook no.	Max. temp., °C.	Yield		Chemical properties of pulp			Physical properties of pulp (at 300 freeness)					
		Total, %	Rejects, %	Roe %	Lignin, %	Pentosan, %	Time, min.	Bulk, cc./g.	Burst factor	Tear factor	Breaking length, m.	Stretch, %
					Original Spruce Sample—Canada Paper Co.							
873	170	53.4	1.0	16.2	13.3	8.4	112	1.31	111	0.85	14,700	3.4
919	165½	55.3	1.7	16.9	13.3	8.0	115	1.38	104	0.86	14,500	2.7
					Spruce Sample II—Canada Paper Co.							
1001	170	55.2	1.1	14.8	12.3	7.6	116	1.42	104	0.81	13,900	3.6
1002	165½	54.8	0.7	13.5	10.9	7.6	119	1.31	110	0.87	15,100	4.1
1004	155	55.5	1.1	14.7	11.8	7.7	120	1.32	107	0.82	15,000	3.7
					Spruce Sample III—Canada Paper Co.							
1026	170	55.2	3.5	16.5	13.2	7.5	Not Tested					
1027	165½	55.6	2.5	16.9	13.4	7.7	Not Tested					
1028	155	56.3	4.2	16.8	13.4	8.0	Not Tested					

Unbleached Pulps—Temperature Series

The results of cooks at 165½ and 155°C. are given in Table II. An examination of the pulping curve on the Ross diagram in Fig. 3 had shown that between yields of, approximately, 75 and 65% the curve was closely parallel to the iso-cellulose lines on the diagram, or to lines of constant residual carbohydrate. Thus the loss in yield occurred, almost entirely, through the removal of lignin. It was evident that if this trend could be extended below 65% yield, then an advantage of up to 4% carbohydrate yield could be expected for the same lignin content. The commencement of the break in the curve corresponded to a temperature of 165½°C. and it was felt that holding at this temperature rather than raising to 170°C., where the maximum rate of removal of lignin occurred, might be advantageous. The H factor (*8*) was used to give times that would result in yields similar to those in the 170°C. series. Then a further series was made at 155°C.

It will be seen that prolonging the cook at the lower temperature of 165½°C. did, in fact, maintain the same trend of continuing along approximately the same iso-cellulose line and hence gave a higher yield for similar lignin content. This is at a variance with other investigators (*1*, *5*) and three additional cooks at a constant H factor were made with each of two new samples of spruce from the same source and having a similar chemical composition to the first lot. The results, given in Table III, show that with the new samples, temperature did not have any yield advantage. Hence the abnormal results in the first series can only be accounted for by some difference in the wood not apparent from the chemical analysis.

Unbleached Pulps—Sulphide Charge Series

Previous experience with the effect of variations in sulphide charge (*3*) indicated that this procedure might alter the lignin-carbohydrate ratio and result in an increased yield for the same lignin content. Two cooks were made with increased sulphide charges and two with decreased charges, all having an effective alkali charge of 17%. The results are given in Table IV and the position of the pulps on the Ross diagram is shown in Fig. 3.

Increasing the sulphide charge to 10% shows a movement to the right of the regular pulping curve and, thus, indicates some increase in the carbohydrate yield. At the same time there was a decrease in the lignin content. However, any advantage would not be economical at the high sulphidity corresponding to 10% sulphide charge, i.e., 46%.

Reducing the sulphide to 3% showed little effect at the high yield. At the lower yield, however, less pulping was done but the position on the diagram was not altered to any extent.

Bleached Pulps

Part (b) of the Objective, i.e., the evaluation of certain of the high-yield pulps after selective removal of the lignin, was accomplished by taking unbleached pulps at four stages in the cycle with the following characteristics:

Cook no.	Time, min.	Yield, %	Lignin, %
879	10	88.9	27.1
869	40	80.4	28.4
867	85½	67.8	22.3
865	96	57.7	17.4

Table IV. Yields and Pulp Quality—Cooks with Variations in Sulphide Charge

Cook no.	Sulphide charge, %, on wood	Yield		Chemical properties of pulp			Physical properties of pulp (at 300 freeness)					
		Total, %	Rejects, %	Roe no.	Lignin, %	Pentosan, %	Time, min.	Bulk, cc./g.	Burst factor	Tear factor	Breaking length, m.	Stretch, %
					Cooks with Increased Sulphide Bharge							
873[a]	6.0	53.4	1.0	16.2	13.3	8.4	112	1.31	111	0.85	14,700	3.4
920	8.0	53.1	0.6	15.5	10.9	8.1	108	1.40	109	0.85	15,200	3.9
921	10.0	52.9	0.3	12.6	9.8	8.2	107	1.36	108	0.90	15,100	3.8
					Cooks with Decreased Sulphide Charge							
867[a]	6.0	67.8	...	28.7	22.3	8.9	128	1.44	83	0.71	12,800	3.1
922	3.0	67.8	...	29.1	24.0	7.8	131	1.52	72	0.73	10,800	3.5
873[a]	6.0	53.4	1.0	16.2	13.3	8.4	112	1.31	111	0.85	14,700	3.4
923	3.0	59.0	4.8	23.6	21.7	7.5	142	1.42	97	0.76	12,600	3.7

[a] Reference cook.

Table V. Yields and Pulp Quality (Bleached)

Sample no.	Bleach time, hr.	Yield, %, on wood	Chemical properties of pulp: Roe no.	Lignin, %	Pentosan, %	α-Cell., %	Physical properties of pulp (at 300 freeness): Time, min.	Bulk, cc./g.	Burst factor	Tear factor	Breaking length, m.	Stretch, %	M.I.T. folds
879[a]	0	88.9	34.0	27.1	9.3	84.1	97	1.96	15	0.45	4,300	1.3	4
879A	10	83.3	16.7	17.7	8.3	83.4	74	1.70	45	0.57	9,400	2.6	131
879B	32	73.7	9.5	7.4	8.9	76.3	52	1.47	66	0.52	12,700	2.5	350
879C	60	69.6	4.3	2.8	9.3	71.9	26	1.39	89	0.52	14,200	3.2	572
869[a]	0	80.4	36.2	28.4	8.5	78.8	115	1.72	41	0.58	8,200	2.5	84
869A	7¼	75.3	18.9	19.8	8.7	76.3	104	1.49	70	0.55	11,800	2.4	540
869B	14	66.2	9.9	9.4	9.4	75.6	56	1.38	92	0.57	14,300	3.3	1130
869C	30	59.6	3.3	1.9	10.1	75.8	30	1.30	110	0.63	16,100	3.1	1700
867[a]	0	67.8	28.7	22.3	8.9	83.4	128	1.44	83	0.71	12,800	3.1	680
867A	2	62.0	10.9	11.4	9.2	81.3	87	1.35	108	0.75	15,500	3.2	1300
867C	20	54.9	2.2	1.7	9.8	81.8	39	1.29	142	0.79	17,200	3.8	2300
865[a]	0	57.7	22.7	17.4	7.8	87.2	126	1.34	100	0.82	14,300	3.6	1160
865A	24	50.2	1.3	0.8	8.4	85.2	60	1.34	135	1.00	16,100	3.5	2820

[a] Unbleached

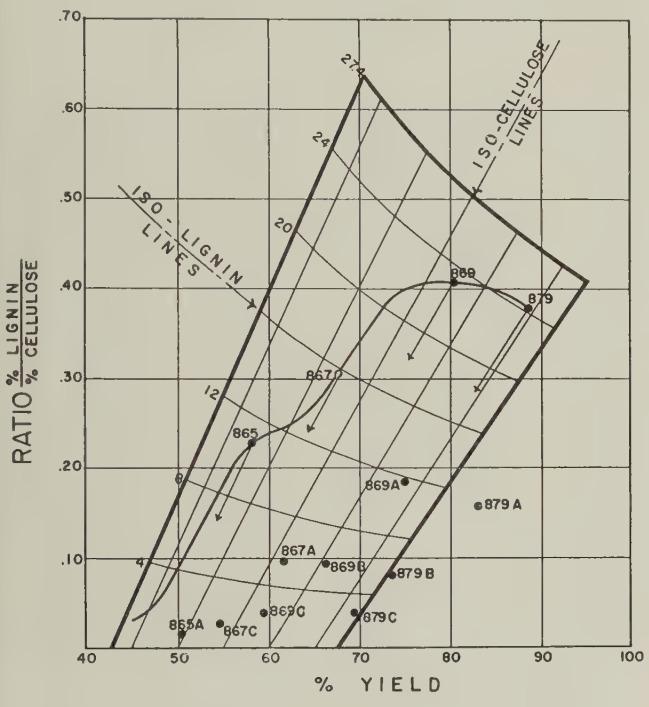

Fig. 6. Ross diagram—chlorite bleach results

The first two pulps, 879 and 869, were bleached by the chlorite process to give a lignin value of, approximately, that of cook no. 867. Then they were further bleached, together with pulp no. 867, to the lignin level of pulp no. 865. Finally all four pulps at this lignin content were bleached to remove nearly all their remaining lignin. The position of the original pulps on the Ross diagram together with the position of the bleached residues are shown in Fig. 6.

It will be noted that in all cases, after bleaching, the position on the diagram has moved to the right of that of the original pulp. This is impossible since it implies a manufacture of cellulose. Also experience over many years has shown that our yield determinations have an accuracy of ±1%. Therefore it is reasonable to assume that the TAPPI lignin procedure is not accurate when dealing with chlorited pulps.

Assuming that the chlorite procedure removes little or no carbohydrate, the position of the bleached residue will fall on the same iso-cellulose line as that of the original pulp. Then if the yields are correct, repositioning of the bleached residues may be made with reasonable accuracy. This is shown in Fig. 7.

The chemical and physical properties of these pulps are given in Table V and of particular interest are the developed burst factors at 300 freeness. These are shown in Fig. 8 where they are plotted against the

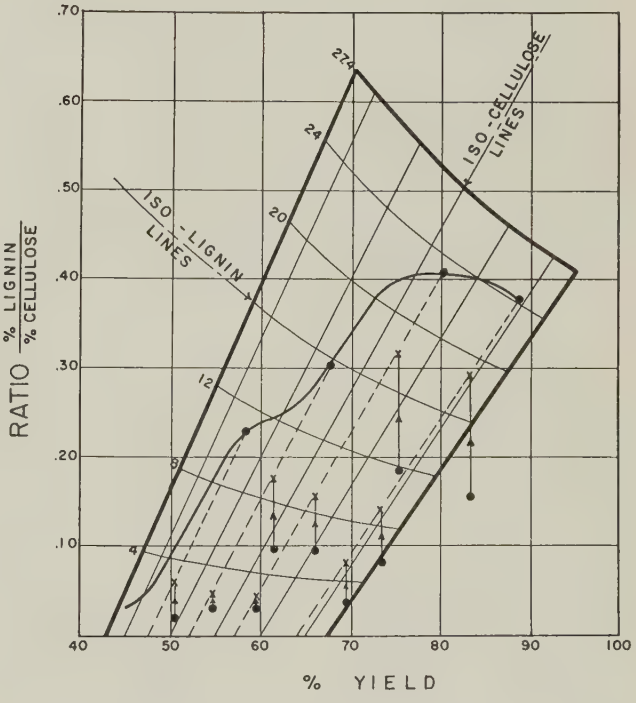

Fig. 7. Ross diagram—corrected chlorite bleach results

Table VI. Comparison of Chlorite and Multistage Bleaching

Sample no.	Method	Yield from wood, %	Chemical properties of pulp: Roe no.	Lignin, %	Pentosan, %	α-Cell., %	1% NaOH soluble	Physical properties of pulp (at 300 freeness): G.E. bright, %	Time, min.	Bulk, cc./g.	Burst factor	Tear factor	Breaking length, m.	Stretch, %	M.I.T. folds
1056	Unbleached	64.4	27.9	22.0	8.6	74.3	...	16.6	190	1.34	96	0.68	12,700	3.4	1040
1056B	$NaClO_2$	50.5	1.6	0.9	9.7	83.6	6.3	70.9	49	1.20	147	0.82	18,200	4.0	2800
1056C	Multistage	48.8	0.9	1.2	8.5	84.6	6.4	75.6	32	1.26	107	0.68	14,200	3.8	...

per cent yield on wood with the unbleached values also shown. It will be noted that as the yield decreases, which in this case is equivalent to the removal of lignin, the burst factor rises. The values appear to fall on a straight line with the maximum at the lowest lignin content. This pulp with a burst factor of 142 and a breaking length of 17,200 is one of the strongest ever tested at the Institute.

In order to compare a chlorite bleached pulp with one bleached in the regular manner, an additional cook was made duplicating conditions of cook no. 867. One portion of the unbleached pulp was given a chlorite bleach and another portion, a conventional, multistage kraft bleach. The results are reported in Table VI and confirm the high strength obtainable through removal of lignin in the chlorite bleach. On the other hand, the conventional bleach does not give these strengths. The results showed, however, that an unbleached kraft pulp of 65% yield can be bleached by conventional methods to a fair brightness level with good strength although the chemical costs would be excessive. The same conclusions were drawn by Limerick (*7*).

GENERAL DISCUSSION

The relationship between the yield, and burst factor for the bleached pulps, shown in Fig. 8, was developed further. Figure 9 shows this relationship, as well as that for the unbleached pulps. In the latter the values for the temperature series and the two wood samples as well as the regular series are plotted.

The developed burst of the unbleached pulps increases with decreasing yield, going through a maximum at, approximately, 51% yield. It is at this point on the Ross diagram that losses in yield become more attributable to loss of carbohydrate and it is reasonable to suppose that some degradation of the cellulose is occuring and, therefore, a loss in strength.

The curve for the bleached pulps rises steadily to a maximum at, approximately, the same 51% yield. No pulps in this investigation having unbleached yields less than 50% were bleached with chlorite.

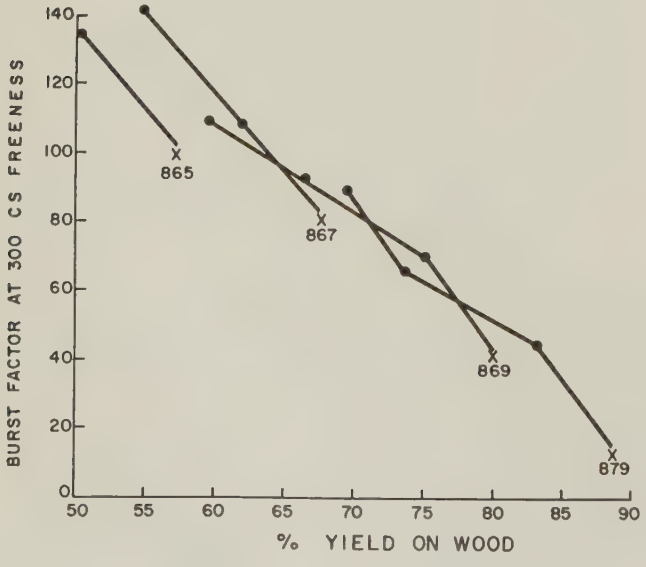

Fig. 8. Developed burst versus per cent yield on wood (bleached)

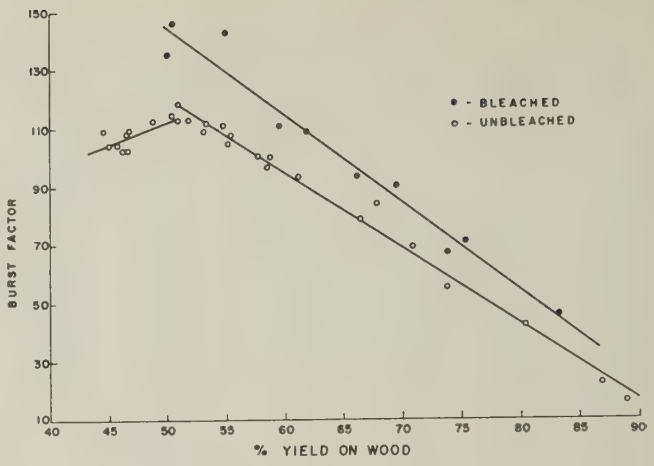

Fig. 9. Developed burst factor versus per cent yield on wood (bleached and unbleached)

However previous experience (*10*) showed that an unbleached pulp of 45% yield and having a developed burst of 102 was raised to 120 by means of a chlorite bleach. Therefore, it would be expected that the bleached pulps in this series would follow the trend shown by the unbleached values.

One further point that is of interest is that the highest strength values for the bleached pulps were obtained from unbleached pulps from which an appreciable amount of lignin had already been removed in the cooking process. The results, in Table VI, show that pulps 869 and 879 never attained the high strength of either 867 or 865 although all were reduced to, approximately, the same low lignin contents. A glance at the position of these pulps on the Ross diagram in Fig. 6 shows that very little lignin has been removed in the cooking of the first two pulps, whereas nearly half the original lignin had been removed in pulp 867. Hence the line of demarcation will lie between 80% yield and 68% yield.

The graphs in Fig. 9 show, unquestionably, that there is a relationship between the yield and the developed burst. However, yield in itself is not a property of the pulp. Therefore there must be some other factor, or factors, present in arriving at any given yield, which are related directly to the burst factor. The removal of lignin, alone, is not the complete answer although it undoubtedly is a contributory one. This has been described by Jayme (*11*); also Ratliff (*12*) has shown a possible correlation between the hemicellulose content and the physical properties. It may be postulated that the physical condition of the fibers after removal of the lignin as well as the means by which it is removed are deciding factors. Further studies along these lines are contemplated.

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Evolutionary Operation: Its Method and Application

TRUMAN L. KOEHLER

The necessity for determining the operating characteristics of a manufacturing process in the plant equipment is well known. Evolutionary operation is even more than a method for optimizing a process without disturbing production. Box in his paper, "Evolutionary Operation," defines the technique in part as "a method of process operation which has a 'built-in' procedure to increase productivity." This paper discusses the philosophy of evolutionary operation, together with some aspects of American Cyanamid's experience with the method.

With the help of George E. P. Box and J. Stuart Hunter, the Organic Chemicals Division of the American Cyanamid Co. began an effort to establish "evolutionary operation" in its manufacturing processes in June, 1957. This paper is a summary of both the method as described by Mr. Box (*1*), and our rather brief experience.

The necessity for determining the operating characteristics of a plant process need hardly be discussed here. Anyone associated with a production process is aware of

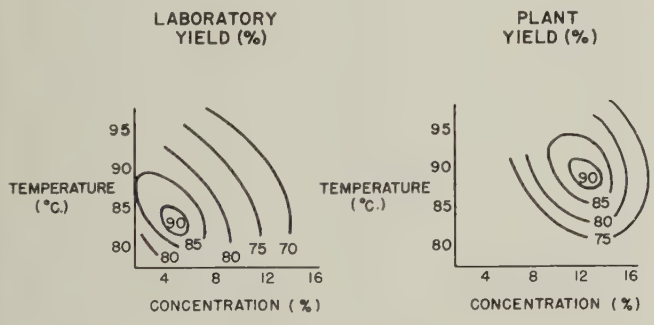

Fig. 1

the difficulty in transferring conditions established in the laboratory or pilot plant into full-scale equipment. The specific nature of this difficulty may be perhaps best illustrated by means of the following "contour" diagram. When a process is transferred from the laboratory into full-scale equipment, unquestionably the relationship between the variables remains approximately the same. For example, if it is found in the laboratory that as the temperature is increased the yield rises to a maximum and then falls, approximately the same relationship will certainly be maintained in plant equipment. However, if 78°C. was optimum as determined by a thermometer inserted in a glass beaker, it does not necessarily follow that 78°C. is the optimum as measured by a thermocouple in a large steel pot. This situation is even clearer when mechanical variables are considered. It requires no imagination at all to see the difficulty in translating the revolutions per minute of a glass stirrer to the agitator of a tank. As a result the contour system describing the relationship between the variables will usually be displaced and even distorted due to scale-up effects.

In the past, the only statistical tool available to determine optimum conditions in the plant was the same designed experiment used in the laboratory or pilot plant. Of course, the major difficulty with a designed experiment is that by its very nature it will upset production for varying lengths of time depending on the complexity of the design. It must be expected that some batches, as designated by the design, will produce very low yields, high levels of impurity, etc. The use of a designed experiment can certainly be justified when faced with a very sick process and the necessity of a reasonably fast cure commonly called a "crash program." However, the vast majority of processes are just slightly ill, and faced with the prospect of an experiment disrupting production, management frequently decides that the cure is worse than the disease. For example, it is very common to find a process producing yields of 80% of theoretical while optimum laboratory conditions will produce 88%. Certainly management would like to approach, if not surpass, the 88%, but if the process is profitable at 80% and sales are heavy the motivation to approve a crash program is weak indeed.

Evolutionary operation is designed for this type of application.

COMPARISON OF NATURAL EVOLUTION WITH EVOLUTIONARY OPERATION

Biologists declare that there are two basic elements in the process of natural evolution: (1) variation and (2) selection. Since no two things are produced exactly alike in nature, there is certainly variation. By some principle, such as survival of the fittest, the undesirable members of the class under consideration are

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gradually reduced in favor of the desirable members. Because the variation and selection are ever continuing, the group gradually moves toward optimum characteristics.

Evolutionary operation emulates this natural process by providing that variation and selection are artificially introduced to the manufacturing process. They are introduced in such a way that there is little danger of producing unsatisfactory material. Consequently, evolutionary operation is regarded as a permanent method of operation which will gradually push the process toward its optimum operating conditions. Since the method is permanent, only techniques which can be readily understood by the manufacturing personnel are used.

GENERAL DESCRIPTION

Slight variation, aside from the normal process variability, is introduced by means of a carefully prescribed pattern. The pattern requires that small changes are made in two or three control variables about the standard operating conditions. Continued manufacture of material under the conditions described by the pattern will allow information to accumulate while material is being produced. To quote from the Box paper: "The effects of the deliberate changes in the variables will usually be masked by large errors customarily found on the full scale. *However, since production will continue anyway, a cycle of variants which does not significantly effect production can be run almost indefinitely, and because of constant repetition the effect of small changes can be detected.*"

The second essential component, selection, is supplied by presenting the data gathered to the process supervisor in an easily interpretable way so that changes toward improved manufacture can be made. Mr. Box suggests an "information board" which will be described in detail later in this paper. In general, accumulated data are continuously recorded on a board in the process supervisor's office in such a way that he can, at any moment, determine the advisability of moving the pattern, the cost of the program, etc.

At American Cyanamid we have adopted the form proposed by Mr. Box with very few modifications. We have in a number of cases taken advantage of the experience of quality control engineers, and have posted the information boards in the manufacturing areas. There have been examples where yields have increased merely because interest in the operation was evidenced.

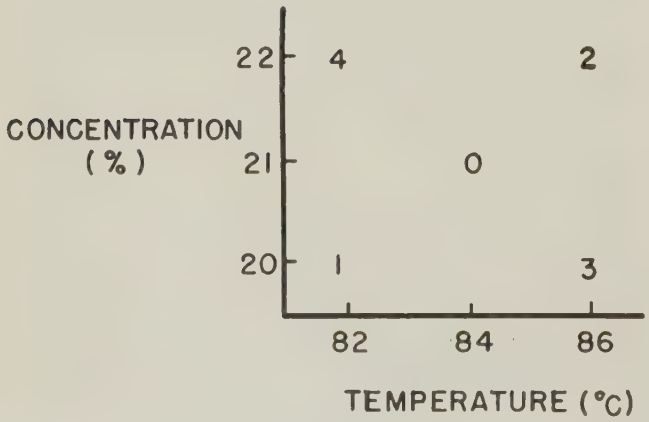


Fig. 2

DETAILS OF THE METHOD

To discuss the details of evolutionary operation, let us consider an example. As has already been mentioned, the first important aspect of evolutionary operation is that changes in control variables are made according to a prescribed pattern. Figure 2 shows a pattern for two controlled variables. Position 0 represents the standard operating conditions of temperature and concentration. Positions 1, 2, 3, and 4 represent changes in the two variables considered to be small with respect to their effect on two responses, yield and per cent impurity. If this is a batch process, batches will be made successively at each of the five positions in the order 0, 1, 2, 3, 4, 0, 1, 2, 3, 4, and so on. Each set of five runs is known as a cycle.

PHASE I — INFORMATION BOARD — CYCLE 7

RESPONSE	YIELD		% IMPURITY	
REQUIREMENT	MAXIMUM		MINIMUM	
RUNNING AVERAGES	CONC (%) 22	525 490	CONC (%) 22	3.8 4.7
	21	530	21	4.1
	20	540 531	20	3.8 4.4
	82 84 86 TEMPERATURE (°C)		82 84 86 TEMPERATURE (°C)	
95% ERROR LIMITS	±20		±20	
EFFECTS WITH 95% ERROR LIMITS — TEMP.	−11.0	±10	0.38	±0.29
EFFECTS WITH 95% ERROR LIMITS — CONC.	−14.0	±10	0.08	±0.29
EFFECTS WITH 95% ERROR LIMITS — C X T	6.5	±10	0.08	±0.29
EFFECTS WITH 95% ERROR LIMITS — CHANGE IN MEAN	6.8	±18	0.06	±0.52
STANDARD DEVIATION	25.9		0.75	

Fig. 3

The data are then tabulated on the "information board" (Fig. 3). In this example, the program is still in phase 1, that is, the pattern is still operating about the original standard conditions. Seven cycles have been completed.

Shown at the top of the table are the responses being considered and the requirements for each. Below that appear the running averages calculated through the seventh cycle. The running averages are posted in such a way as to make the relationship between the variables as clear as possible. The reliability of each average is measured by the quantity called the "95% error limits." These are calculated by use of the formula $\pm ts/\sqrt{n}$, where n is the number of cycles completed, s is the standard deviation, and t is the appropriate quantity chosen from a table of the t distribution. A variety of probability levels are available in the table. It is clear from the formula that the program can be continued until the quantity, $ts/\sqrt{n}$, is reduced to any desired size.

Following this are the "effects" and their 95% error limits. If the average at any point, i, is denoted by $\bar{y}_i$, the effects and the error limits may be calculated by the following formulas:

Source	*Effect*	*Error limits*
Temperature	$^1/_4(\bar{y}_2 + \bar{y}_3 - \bar{y}_1 - \bar{y}_4)$	$\pm ts/2\sqrt{n}$
Concentration	$^1/_4(\bar{y}_2 + \bar{y}_4 - \bar{y}_1 - \bar{y}_3)$	$\pm ts/2\sqrt{n}$
Interaction	$^1/_4(\bar{y}_1 + \bar{y}_2 - \bar{y}_3 - \bar{y}_4)$	$\pm ts/2\sqrt{n}$
Change in mean	$^1/_5(\bar{y}_1 + \bar{y}_2 + \bar{y}_3 + \bar{y}_4 - 4y_0)$	$\pm 2ts/\sqrt{5n}$

The numerical value of the temperature and concentration effects estimate the change in the response when the conditions are shifted from the center position to either the high or low level. The interaction effect measures the dependence of the two variables. Finally, the change in mean, which is merely the difference between the average of all the runs and the average at the center conditions, measures the change in the average response due to introducing evolutionary operation.

The error limits aid in evaluating the effect in the following way. The effect ± the error limits provide two values which represent the limits of a confidence interval. Since the effects as calculated are only estimates of the true effects, any value contained within the interval is considered a possible value for the true effect. Any value outside the interval is not acceptable as a hypothesized value for the true effect. As long as zero is included in the interval, it is agreed that at the given probability level, the variable in question may have no effect. Therefore, the exclusion of zero in the confidence interval usually supplies the criterion for action.

A few comments should be made to relate these effects to the geometry of the surface of the response variable. If the surface in the locale of the evolutionary operation pattern is planar, it may be completely described by the two main effects. In this case the path toward improved operation is quite clear. If, on the other hand, the confidence intervals about the change in mean or interaction effects exclude zero, the assumption of planarity is not tenable. While the running averages will provide hints as to the nature of the nonplanarity, a technique previously described (*2*) is used for further exploration.

On the basis of the data supplied on the information board, the process supervisor can decide whether the process should continue to cycle around the initial pattern or whether the operation should be modified. If the decision is for modification, several possible choices are:

1. Relocate the pattern so that one of the corner points becomes the new center.
2. Lengthen the interval over which one or both of the variables are being examined.
3. Explore a path that is indicated as leading toward improved conditions.
4. Replace the old variables with new ones.

In addition, if the program contains only two control variables, every effort should be made to add a third. It was our experience at American Cyanamid that two-variable programs are probably to be preferred for inauguration purposes. As production personnel have become familiar with the technique, however, we have encouraged them to take advantage of the increased efficiency of the three-variable pattern.

SELECTION OF CONTROL VARIABLES

When it has been agreed that an evolutionary operation program should be initiated on a given process, a choice of control variables must be made. As the program proceeds, the effect of these variables will decrease as they approach their optimum levels. Consequently, when their possible additional contribution reaches an economic minimum, they will be dropped from the program in favor of new variables. Consequently a continuing supply of ideas regarding possible control variables is essential. For this purpose Mr. Box recommends that "evolutionary operation committees" be established.

These committees are comprised of people of different disciplines with interest in the process. The nucleus of such a committee might be the process supervisors, a research chemist thoroughly familiar with the reaction, and a chemical engineer who has had experience with the type of equipment used in the process. The major function of this committee is to advise the process supervisor in the operation of the program. During meetings, held monthly perhaps, for the purpose of interpreting the results, ideas for modification of the program will be generated.

In those areas of production in which we view the performance of evolutionary operation as less than ideal, there is one common deficiency—no functioning evolutionary operation committee. It has become quite clear that when there is no feedback of ideas to research, when little thought is given to the selection of new variables, the life blood of evolutionary operation is cut off. The establishment of these committees in all areas heads our list of things to be done.

An example might be given of the function of the evolutionary operation committee. In a particular process in which the main reaction was carried out in a large steel tank, one of the conditions of interest was the agitation rate. The agitator, as in most large-scale units, did not have a variable speed drive, however, and a capital expenditure to install one for investigative purposes was out of the question. Consequently, the process supervisor decided that agitation could not be examined. In casual conversation with a chemical engineer of considerable experience, the suggestion was made to merely insert an air line in the tank and sparge the contents in addition to the normal agitation. This system provides the upper and lower levels of an evolutionary operation pattern, and even a center point if the air pressure is regulated. On the basis of this trial, it will become clear whether or not additional money should be spent to allow optimization of the agitation rate. This kind of suggestion cannot be allowed to occur by chance.

Periodically, people in addition to the nucleus already described could contribute to the meetings. An accountant, a statistician, and a person familiar with the quality aspects of the product are examples.

AN EXAMPLE OF AN ACTUAL PROGRAM

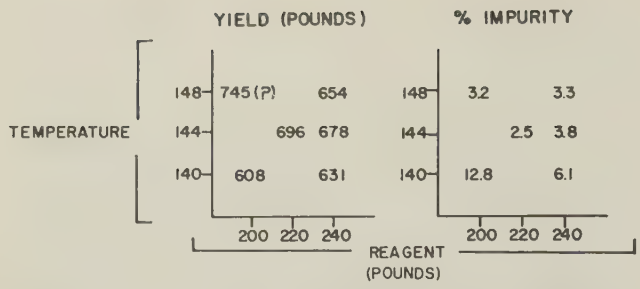
In setting up an evolutionary operation project on product A, two control variables were chosen: (1) temperature (2) pounds of reagent.

The yield is to be maximized and the per cent impurity minimized. There is an upper specification limit of 3% on the impurity. While temperature levels were chosen so as to straddle the standard conditions, in a bit of wishful thinking the standard raw material usage was set as the upper level for the pattern. As a result, we started with the unusual six-point pattern shown on the following diagram.

Only two cycles in phase I appeared on following page.

While the confidence interval about the temperature excludes zero, this was not our reason for deciding that a revision in levels was necessary. Although the yields at the low temperature may or may not be low, the impurity levels far exceed the specification limit of 3%.

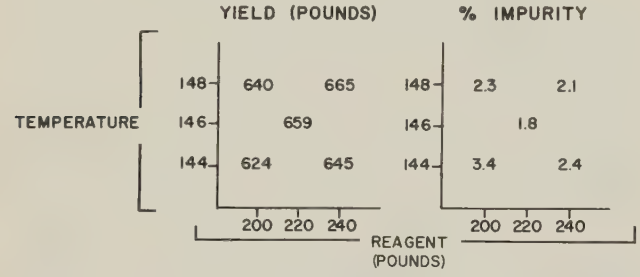
Since there was no real indication that higher tem-



SOURCE	EFFECT	95% ERROR LIMITS	EFFECT	95% ERROR LIMITS
REAGENT	-17	±33	-1.7	±2.34
TEMPERATURE	40	±33	-3.1	±2.34
R X T	-28	±33	1.7	±2.34
C. I. M.	-29	±59	3.1	±4.18

perature was beneficial (only that lower temperature was maleficial), the pattern was changed by raising the temperature lower limit to 144 and leaving the upper limit at 148. This decision was strengthened by the fact that the two batches run at 148° and 200 lb. both received overcharges of a second raw material.

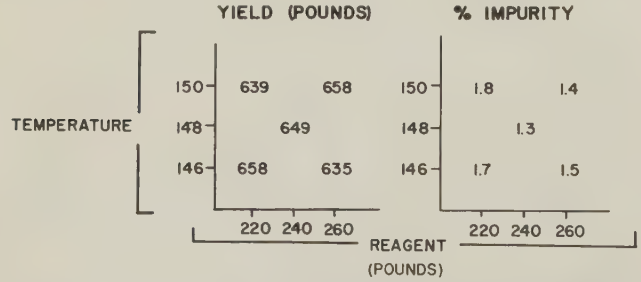
Nine cycles of phase II produced these averages.



SOURCE	EFFECT	95% ERROR LIMIT	EFFECT	95% ERROR LIMITS
REAGENT	11	±14	-0.30	±0.30
TEMPERATURE	9	±14	-0.35	±0.30
R X T	1	±14	0.21	±0.30
C. I. M.	-12	±25	0.58	±0.55

Both the reagent and the temperature effects indicated that increases would decrease the per cent impurity. Their effects on yield, while not real at the 95% level, indicated that we might expect yield increases as well. Thus the pattern was shifted upward 2° in temperature with an additional 20 lb. of reagent.

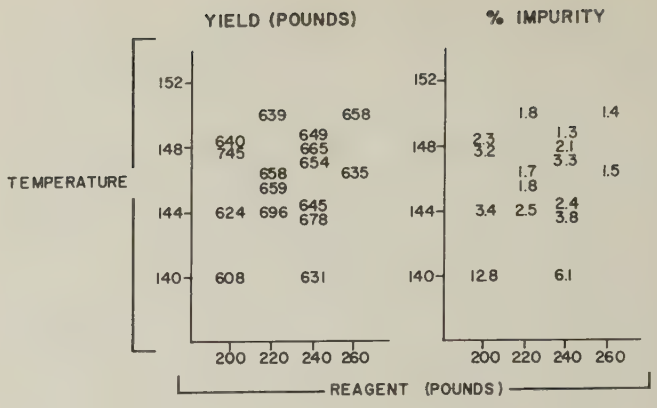
The averages after 11 cycles of phase III appeared:



SOURCE	EFFECT	95% ERROR LIMITS	EFFECT	95% ERROR LIMITS
REAGENT	-1	±11	-0.15	±0.24
TEMPERATURE	1	±11	0	±0.24
R X T	11	±11	-0.05	±0.24
C. I. M.	-1	±20	0.24	±0.43

The only real effect is the interaction between reagent and temperature on yield.

Looking at a summary of the averages to date it is



clear that the per cent impurity has been sharply reduced. However, it is not clear what has happened to the yields. The following points may be observed.

1. Yields over the 6 months prior to the project averaged 672 lb. at 144° and 240 lb.
2. The average of nine cycles of phase II at this point was 645 lb.
3. Those conditions which were repeated in both phase II and phase III agree very well.

It was suspected that the yields were depressed across the board by some uncontrolled variable, approximately between phase I and phase II. To check this assumption, the center point of the phase III pattern was alternated with the old standard conditions. The original conditions were now found to average 630 lb., while the center position of phase III averaged 655 lb.

We were convinced that a block effect did exist, but that evolutionary operation also secured a yield increase of about 20 lb. The next phase could have been to elaborate on the evolutionary operation pattern to gain information about the apparent ridge. However, the prospect of finding a variable strong enough to produce the indicated block effect was much more exciting. As a result, a third variable, addition rate, was added to temperature and pounds reagent. On this process, evolutionary operation is being viewed as a mechanism for screening variables for importance.

CONCLUSION

Our experience with evolutionary operation has been most gratifying. Unfortunately, our program is still too immature to report the over-all economic gain. There is little doubt that it will be considerable. Perhaps it is equally important to point out that the concept of evolutionary operation is gradually being instilled as a normal method of production. We feel quite confident that evolutionary operation will be increasingly expanded in our manufacturing area.

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1. Box, G. E. P., "Evolutionary Operation: A Method for Increasing Industrial Productivity," *Applied Statistics* (1957).
2. Box, G. E. P., Connor, L. R., Cousins, W. R., Davies, O. L. (Editor), Himsworth, F. R., and Sillito, G. P., "The Design and Analysis of Industrial Experiments." Oliver and Boyd, Edinburgh and London (1954).
3. Hunter, J. S., "Some Statistical Principles Underlying Evolutionary Operations." Transactions of the Second Stevens Symposium on Statistical Methods in the Chemical Industry (1958).

Presented at the 43rd Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 17–20, 1958.

ASSOCIATION NEWS AND EVENTS

National Conferences

Tenth Coating Conference, Statler Hotel, Boston, Mass., May 25–27, 1959.

Tenth Testing Conference, Multnomah Hotel, Portland, Ore., Aug. 17–21, 1959.

Fundamental Research-Wet Strength Conference, I.P.C., Appleton, Wis., Sept. 9–11, 1959.

Ninth Corrugated Containers Conference, Jung Hotel, New Orleans, La., Sept. 15–17, 1959.

Fourteenth Paper-Plastics Conference, Edgewater Beach Hotel, Chicago, Ill., Sept. 21–23, 1959.

Fourteenth Engineering Conference, Penn-Sheraton Hotel, Pittsburgh, Pa., Oct. 12–15, 1959.

Thirteenth Alkaline Pulping Conference, Robert Meyer Hotel, Jacksonville, Fla., Nov. 4–6, 1959.

Local Section Meetings

Pacific: Gearhart, Ore., May 21–23, 1959, "Multiple Water Use." Joint TAPPI-Superintendents annual meeting.

Golden Gate District (Pacific Section): May 5, 1959.

Kalamazoo Valley: Inman's Restaurant, Galesburg, Mich., April 23, 1959 "Papermaking Felts" Hotel Harris, Kalamazoo, Mich., May 14, 1959, Recognition Night for Western Michigan University award winners.

Chicago (Chicago Bar Association, 29 So. LaSalle St., Chicago, Ill.): April 7, 1959; May 5, 1959.

St. Louis District (Chicago Section) Le Chateau Restaurant, 10405 Clayton Road, St. Louis (all meetings): "Nondestructive Testing of Paper," by Arthur C. Dreschfield, The Glidden Co., Chicago, Ill., April 16, 1959.

Maine-New Hampshire: Samoset Hotel, Rockland, Me., June 12–13, 1959.

New England: Roger Smith Hotel, Holyoke, Mass., April 10, 1959; June, 1959. Place and date to be determined.

Eastern District (New England Sdection): June 1959, annual meeting with New England Section.

Southeastern: Jekyll Island Hotel, Jekyll Island, Ga., May 8, 1959.

Gulf Coast District (Southeastern Section): New Orleans, La., May 15, 1959.

Virginia-Carolina: Franklin, Va., May 15, 1959. Visit to mill of Union Bag-Camp Paper Corp.

Lake Erie: Carter Hotel, April 17, 1959, "Characteristics of Clupak Paper, What Is It? What Is Its Future?"

Papermakers and Associates of Southern California: Los Angeles, Calif., May 21, 1959.

Lake States: Appleton, Wis., April 14, 1959, "Engineering"; Menasha, Wis., May 12, 1959, C. J. West Award Meeting.

Delaware Valley (all meetings held at Engineers Club, Philadelphia, Pa.): April 23, 1959; May 22, 1959.

Ohio: American Legion Hall, Middletown, Ohio, April 14, 1959; Hartwell Reaction Center, Cincinnati, Ohio, May 14, 1950, Annual Meeting.

Indiana District (Ohio Section) (meetings at the Hunt Room, Marott Hotel, Indianapolis, Ind.): April 23, 1959; May 19, 1959; and June 16, 1959.

Empire State: Whiteface Inn, Whiteface, N. Y., June 11–14, 1959. Annual meeting.

Empire State (Central District) (all meetings to be held at the University Club, 431 East Fayeette St., Syracuse, N. Y.): April 3, 1959, visit to mill of Armstrong Cork Co., Fulton, N. Y. Dinner meeting at Fulton Chamber of Commerce; May 1, 1959, "Senior Night," NYSCF; May 21, 1959, annual meeting of Fulton C. of C., Fulton, N. Y.

Empire State (Metropolitan District) (all meetings to be held at 465 Lexington Ave., New York, N. Y.): April 14, 1959, "Development in the Printing Industry"; May 12, 1959; Annual Meeting.

Empire State (Northern District) (all meetings to be held at Woodruff Hotel, Watertown, N. Y.): Northern District Awards Program, April 9, 1959; Annual Meeting May 14, 1959.

Empire State (Eastern District) (all meetings to be held at Queensbury Hotel, Glens Falls, N. Y.): Ladies' Night, April 18, 1959; Annual Symposium, subject to be announced, May 21, 1959.

Empire State (Western District) (all meetings at the Prospect House, Niagara Falls, N. Y., unless otherwise indicated): Annual Ladies' Night—April; Field Trip—May (Details to be announced later).

Other 1959 Conferences

June 17–20	CPPA Summer Meeting, Manor Richelieu Hotel, Murray Bay, P. Q.
Sept. 13–18	Am. Chem. Society, Atlantic City, N. J.
Oct. 11–16	ASTM, San Francisco, Calif.
Oct. 26–28	Packaging Institute, Statler Hotel, New York, N. Y.
Nov. 9–11	National Paperboard Assoc., New York, N. Y.

TAPPI 1959 Executive Committee

As reported by the Tellers Committee, James R. Lientz, Union Bag-Camp Paper Corp., Savannah, Ga., and Harold M. Annis, Oxford Paper Co., New York, N.Y., were elected president and vice-president of the Technical Association.

Members of the Executive Committee whose terms continue are: B. T. Briggs, Rayonier, Inc., Shelton, Wash.; P. S. Cade, Harding-Jones Paper Co., Middletown, Ohio; K. G. Chesley, Crossett Co., Crossett, Ark.; J. R. Curtis, Scott

J. R. Lientz, Union Bag-Camp Paper Corp.

H. M. Annis, Oxford Paper Co.

Annual Luncheon at the 44th Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 26, 1959

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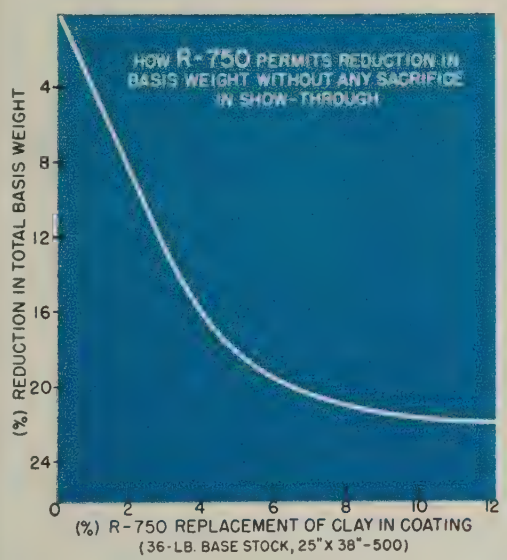

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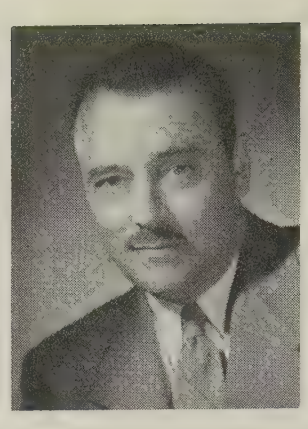

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Paper Co., Chester, Pa.; F. P. Doane, Jr., Bergstrom Paper Co., Neenah, Wis.; J. H. Heuer, Great Northern Paper Co., Millinocket, Me.; J. J. Koenig, Gaylord Container Corp. Div., Crown Zellerbach Corp., St. Louis, Mo.; and J. P. Weidner, Container Corp. of America, Brewton, Ala.

The members of the committee whose terms expired in February, 1959, were P. S. Bolton, Continental Can Co., Uncasville, Conn.; O. W. Callighan, Minerals & Chemicals Corp. of America, Kalamazoo, Mich.; and H. S. Spencer, Howard Smith Paper Mills, Beauharnois, P. Q., Canada; (H. M. Annis became vice-president).

The new members of the committee are Walter C. Bloomquist, General Electric Co., Philadelphia, Pa.; Frederic S. Klein, Byron Weston Co., Dalton, Mass.; Lucien G. Rolland, Rolland Paper Co., St. Jerome, P. Q., Canada and Harris O. Ware, Beveridge Paper Co., Indianapolis, Ind.

Report of Tellers Committee

James V. Cundelan, Rayonier, Inc.; Rex Vincent, Buckley, Dunton Pulp Co.; and Rolf G. Westad, Borregaard Co., all of New York City, constituted the membership of the 1959 Tellers Committee and reported:

"We, the members of the Tellers Committee, having made a canvass of the official ballots for officers and members of the Executive Committee for 1959 of the Technical Association of the Pulp and Paper Industry, have found that the following persons have received a majority of the 1296 votes cast:

President: James R. Lientz, Union Bag-Camp Paper Corp., Savannah, Ga.
Vice-President: Harold M. Annis, Oxford Paper Co., New York, N.Y.
Executive Committee (to serve three years):
Walter C. Bloomquist, General Electric Co., Philadelphia, Pa.
Frederic S. Klein, Byron Weston Co., Dalton, Mass.
Lucien G. Rolland, Rolland Paper Co., St. Jerome, P. Q., Canada
Harris O. Ware, Beveridge Paper Co., Indianapolis, Ind.

Maine-New Hampshire

The spring meeting of the Maine-New Hampshire Section of TAPPI will be held at the Samoset Hotel in Rockland, Me., on June 12–13, 1959.

The technical program entitled "Control of Production Losses" will be under the direction of C. T. Bockus, Eastern Fine Paper & Pulp Div., Standard Packaging Corp. The Industrial Engineering and Materials Handling Session will be directed by M. C. White, Oxford Paper Corp. Panel discussions will be held on Saturday morning.

On the social side there will be a golf tournament, boating and facilities for fishing trips, ladies' program, Friday evening banquet followed by dancing.

Committee on arrangements will be:

B. A. Taylor, James A. Taylor & Sons
J. F. Wright, National Aniline Div.
P. J. Shirley, Penick & Ford Ltd.

Association Staff

James R. Lientz, new president of TAPPI, announces that Dr. R. G. Macdonald, formerly secretary-treasurer of the organizaton, has been elevated to the newly created position of assistant to the president. In this capacity Dr. Macdonald will continue as Editor of *Tappi*. In addition, he will guide and counsel the president and the headquarters staff in all TAPPI activities for which his many years of experience have well fitted him. Mr. Lientz also announces that Dr. P. E. Nethercut, formerly assistant secretary of TAPPI, has been named secretary-treasurer. In this capacity he will direct all activities of the association's staff.

P. E. Nethercut

Corrosion Committee

E. W. Hopper has been appointed chairman of the Corrosion Committee replacing L. Dela Grange, West Virginia Pulp and Paper Co., New York, who has been chairman for the past two years.

Mr. Hopper brings to his new TAPPI job a rich experience in the field of corrosion in the pulp and paper industry. He served on the Chemical Engineering Subcommittee on Alkaline Digester Corrosion almost from its inception and presented several papers on digester corrosion. He maintained his committee membership when the subcommittee was given full committee status two years ago and has been equally active on the Corrosion Committee.

Mr. Hopper studied chemical engineering and geology at Pratt Institute and Columbia University. He was an assistant to Colin G. Fink and to Lincoln T. Work at Columbia University. With Fink, they jointly developed a process for the continuous production of electrolytic tin plate which resulted in the first commercial strip tin plate operation in the world. He was superintendent and technical director of the Tin Plate Department of Crucible Steel Co.

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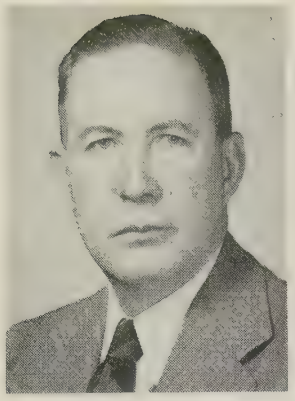


E. W. Hopper, Consulting Engineer

H. W. Fritts, Aluminum Co. of America

from 1945 to 1955 and responsible for the development of applications for stainless and corrosion resistant alloys in the chemical and process industries.

Since 1955, he has operated as an independent consulting engineer in the fields of chemical metallurgical and corrosion engineering. He is a licensed Professional Engineer in the State of Pennsylvania, a member of the Technical Association of the Pulp and Paper Industry, the American Chemical Society, and the National Association of Corrosion Engineers. He was granted several patents on electrolytic tin plate.

Harry W. Fritts, Aluminum Co. of America, New Kensington, Pa., has been appointed secretary of the Corrosion Committee by E. W. Hopper, chairman.

Mr. Fritts has been with Alcoa since 1948, working as a development engineer on applications of aluminum in the pulp and paper, chemical, petroleum, and process industries. He graduated from Columbia University with a B.S. in chemical engineering in 1945 and an M.S. in industrial management in 1948, and served in the United States Navy during World War II.

Mr. Fritts has authored a number of pages on applications and corrosion resistance of aluminum alloys in the process industries. He is a member of TAPPI, NACE, AIChE, and ACS.

Tenth Coating Conference

Frank Kaulakis, general chairman of the Tenth Annual TAPPI Coating Conference, has announced that Stanton W. Mead will address the coating group at their annual luncheon on Wednesday, May 27, 1959.

Mr. Mead, paper manufacturer, director, president, and general manager of Consolidated Water Power & Paper Co., Wisconsin Rapids, Wis., was born in Rockford, Ill, in 1900.

His early education was in Wisconsin Rapids schools. Leaving the city he attended Hotchkiss Preparatory School prior to enrollment in Yale University.

Following graduation from Yale in 1922, Mr. Mead began his career in the paper industry when he joined Consolidated Water Power & Paper Co. He was elected a director in 1927 and has been on the Board continuously since that time. As an executive he has served the company as treasurer for 19 years and as vice-president for 11 years. In 1950 he was elected president and general manager.

Throughout his career Mr. Mead has taken a vital interest in conservation programs in Wisconsin, particularly in the field of forest management. He was instrumental in the founding of "Trees for Tomorrow, Inc.," a nonprofit organization of Wisconsin paper and power companies dedicated to the advancement of reforestation in Wisconsin. He has been a director of this organization since its inception. Within the company he has advocated and fostered sound forest management techniques to provide sustained yields from company-managed lands.

During this 37 years as a paper manufacturer Mr. Mead has given time and energy to the successful development of the Wisconsin River to control flood waters and secure an even supply of water for power purposes. He has served since 1950 as a director of Wisconsin Valley Improvement Co., the company which developed the reservoir system and which regulates the river's flow for the greatest good of the largest number of water users. His relentless efforts have contributed greatly to the efficient development of this natural resource with private capital.

Mr. Mead has been active in stream improvement programs of Sulphite Pulp Manufacturers' Research League, an organization of United States sulphite pulp mills which exists to find economic, nonpollutional uses for by-products of the sulphite pulping process. He has been a trustee of this organization since it was organized in 1939 and has served as its president since 1954.

Outside of business Mr. Mead has taken a keen interest in education, civic projects, and youth programs. He was named a trustee of Lawrence College in 1953 and is a director and vice-president and treasurer of South Wood County YMCA. Mr. Mead has been a capable and long-time leader in the Boy Scout program on the local, district, and council levels. In 1950 he was awarded Boy Scouts of America Silver Beaver award for outstanding service to scouting programs. He was president of Samoset Council, Boy Scouts of America from 1954 through 1957 and has been serving on Boy Scouts of America Region VII Executive Committee since 1957.

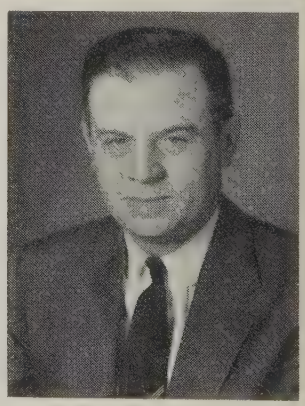
The Tenth Annual TAPPI Coating Conference will be held at the Statler Hilton, Hotel, Boston, Mass., from Monday, May 25, 1959, through Wednesday, May 27, 1959. Those desiring to attend the conference are requested to make their hotel reservations directly with the Statler Hilton. Early reservations are suggested as this promises to be the largest coating conference of TAPPI.

Fourteenth Engineering Conference

M. H. Fisher, Westinghouse Electric Corp., East Pittsburgh, Pa., has been appointed Conference Arrangements chairman by J. R. Curtis, Scott Paper Co., Chester, Pa., for the 14th TAPPI Engineering Conference to be held in the Penn Sheraton Hotel in Pittsburgh, Pa., Oct, 11–15, 1959.

Mr. Fisher was graduated from Alabama Polytechnic Institute in 1941 with a B.S. Elect. Eng. degree and he received his Masters degree from the University of Pittsburgh in 1948. He is a graduate of the Westinghouse Student Course and was motor design engineer from 1942 to 1947. From 1948 to 1952 he was paper mill application engineer

S. W. Mead, Consolidated Water Power & Paper Co.



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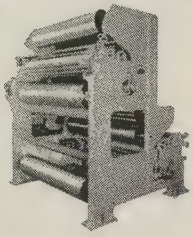

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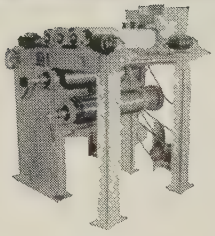

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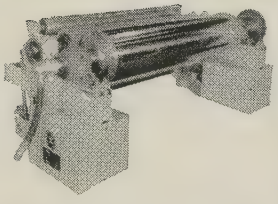

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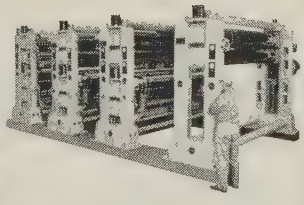

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and since that time he has been section manager of the Industrial Engneering Dept.

Mr. Fisher is a registered professional engineer and is a member of TAPPI, AIEE, and NSPE.

Mr. Fisher has been an active, willing worker in the Engineering Division, specializing in the activities of the Electrical Engineering Committee. He was secretary of this committee during 1956 and 1957 and is a member of the Steering Committee of that group.

Report of the Standards Committee

The Regulations Governing Standards have been revised and have received the general approval of members of the Standard Committee. No major changes are made but a number of minor changes, covering the present practice as gradually developed since 1956, are given in greater detail. Approval by the Executive Committee is required.

All the new revised methods approved by the Standards Committee during 1957 were published in *Tappi* by July, 1958. On Jan. 1, 1959, only seven new or revised methods, completed in 1958, await publication: T 2 m, T 7 m, T 20 m, T 21 m, T 425 m, T 600 m, and T 612 m.

All the methods completed in 1957 were published in loose-leaf form in November, 1958, together with the revised Alphabetical and Numerical Index of TAPPI Standards and Suggested Methods. That loose-leaf issue included five new methods: T 234 sm, T 235 m, T 652 sm, T653 sm, and T 654 sm, nine revisions: T 203 m, T 223 m, T 231 m, T 232 m, T 445 sm, T 484 m, T 636 m, T 639 sm, T 644 m; and nine corrected methods: T 205 m, T 210 m, T 218 m, T 228 m, T 441 m, T 449 m, T 606 m, T 627 m, and T 631 m.

These five new, nine revised, and nine corrected methods in the 1958 issue, compare with a past annual average performance of 5.9, 4.4, and 11.5, respectively. Of these 14 new or revised methods, the Joint ASTM-TAPPI Wax Testing Committee sponsored six, the Chemical Methods Committee four, the Pulp Testing Committee three, and the Microscopy Committee one.

The following methods or standards are, or probably will be, ready for publication and general mailing in loose-leaf form in 1959:

New Suggested Methods

T 21 sm, Weight of Unit Volume of Chips; Fibrous Materials Testing Committee (approved by Standards Comdards Committee December, 1958; to be published in *Tappi*).

T 490 sm, Smoothness of Paper under 3 p.s.i. Clamping Pressure; Paper Shipping Sack Testing Committee (Published in *Tappi*, September, 1958.)

Revised Official Standards (subject to approval by TAPPI membership).

T 2 m, Methoxyl Groups in Wood; Chemical Methods Committee (approved by Standards Committee December, 1958; to be published in *Tappi*).

T 3 m, Moisture in Wood Chips and Sawdust by Toluene Method; Chemical Methods Committee (published in *Tappi*, September, 1958).

T 7 m, Weight-Volume Measurements of Pulpwood; Fibrous Materials Testing Committee (approved by Standards Committee December, 1958; to be published in *Tappi*).

T 15 m, Ash in Wood; Chemical Methods Committee (published in *Tappi*, July, 1958).

T 208 m, Moisture in Pulp by Toluene Method; Chemical Methods Committee (published in *Tappi*, September, 1958).

T 211 m, Ash in Pulp; Chemical Methods Committee (published in *Tappi*, July, 1958).

T 220 m, Physical Testing of Pulp Handsheets; Pulp Testing Committee (published in *Tappi*, September, 1958).

T 227 m, Freeness of Pulp; Pulp Testing Committee (published in *Tappi*, August, 1958).

T 413 m, Ash in Paper; Chemical Methods Committee (published in *Tappi*, July, 1958).

T 425 m, Opacity of Paper; Optical Properties Committee (approved by Standards Committee August, 1958; to be published in *Tappi*).

T 439 m, Titanium Pigments in Paper; Chemical Methods Committee (published in *Tappi*, September, 1958).

T 452 m, Brightness of Paper and Paperboard; Optical Properties Committee (published in *Tappi*, July, 1958).

T 600 m, Analysis of Formaldehyde; Nonfibrous Materials Testing Committee (approved by Standards Committee July, 1958; to be published in *Tappi*).

T 602 m, Analysis of Sulphuric Acid; Nonfibrous Materials Testing Committee (published in *Tappi*, July, 1958).

T 608 m, Calibration of Volumetric Glassware and Analytical Weights; Nonfibrous Materials Testing Committee (published in *Tappi*, June, 1958).

T 609 m, Indicators for Volumetric Analysis; Nonfibrous Materials Testing Committee (published in *Tappi*, June, 1958).

T 612 m, Analysis of Soda Ash; Nonfibrous Materials Testing Committee (approved by Standards Committee July, 1958; to be published in *Tappi*).

T 630 m, Melting Point of Paraffin Wax; Joint ASTM-TAPPI Wax Testing Committee (Published in *Tappi*, January, 1958).

REVISED TENTATIVE STANDARD

T 20 m, Compression Wood in Pulpwood; Fibrous Materials Testing Committee (approved by Standards Committee December 1958; to be published in *Tappi*).

Of these 21 new or revised methods for the 1959 loose-leaf issue, the Chemical Methods Committee, which has 50 methods under its jurisdiction, sponsored seven; the Nonfibrous Materials Testing Committee, with 37 methods, sponsored five; the Fibrous Materials Testing Committee, with six, three; the Pulp Testing Committee with eight, two; the Optical Properties Testing Committee with eight, two; the Joint ASTM-TAPPI Wax Testing Committee with ten, one and the Paper Shipping Sack Testing Committee produced their one method. If a few new or revised methods has been contributed by the Paper Testing Committee, which has 37 methods under its jurisdiction, this could have been a year of record accomplishment.

Grateful acknowledgment is made by the committee for the help given in processing the various methods, by the TAPPI headquarters staff, and, in particular, for the careful interest of A. J. Winchester.

The committee welcomed the active participation of Edwin C. Jahn and W. Boyd Campbell in its work for the year, but has missed that of James P. Casey who had to resign early in 1958 because of added other work.

It is with the deepest regret that we record the passing away of our eldest member, Edwin Sutermeister, whose acute, friendly criticisms and helpful suggestions were always most welcome.

Bert L. Browning
W. Boyd Campbell
Gardner H. Chidester
Walter F. Holzer
Edwin C. Jahn
Joseph L. McCarthy
William R. Willets
James d'A. Clark, *Chairman*

Joint Textbook Committee

The accompanying report of textbook sales and financial statement for 1958 indicates that the committee, sponsoring the publication of the four-

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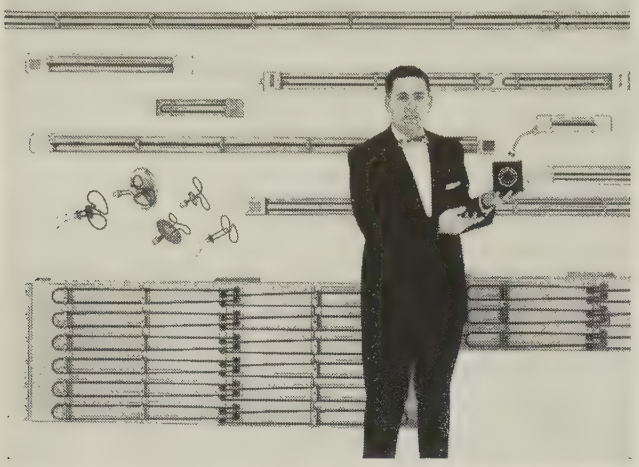

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volume texts "Pulp and Paper Manufacture," had another very successful year.

Textbook sales continued very well during 1958 with a total of 2728 volumes sold during the year.

The financial assets as at Dec. 31, 1958, amounted to $16906.81 with no outstanding or unpaid accounts. This figure indicates an increase in assets of $3754.69 for the 12 month period. Income is derived from royalties and bank interest and the assets of the committee are retained to provide for future revisions at appropriate times deemed advisable by the committee.

There were no changes in the personnel of the committee during 1958.

On behalf of the committee, we herewith express our thanks to those who have assisted us in the past, and special thanks are extended to the publishers, McGraw-Hill Book Co. Inc., and to the editor, J. Newell Stephenson.

Textbook Sales

Throughout 1958 textbook sales have held up very well. The sale of 2728 volumes during the year results in a total of 36,740 volumes of the fourth edition solid since the publication of revised volume 1 in 1950. Details of textbook sales are given below.

First three editions→		Total all volumes 51,356	
	1958 Sales	*Total sales*	
Fourth edition			
Volume I	664	11,427	
Volume II	501	8,876	
Volume III	588	8,052	
Volume IV	311	4,893	
Total	2064	33,248	
Four volume library sets	664 (166 sets)	3,292 (823 sets)	
Total	2728	36,540	
Grand total all editions			87,896

DOUGLAS JONES, *Secretary-Treasurer*

Financial Statement 1958

Cash on hand Jan. 1, 1958			$13152.12
Income			
Royalties	$ 3693.14		
Bank interest	455.90		
			4149.04
Expenditures			
Editor's consulting fee	300.00		
New letterhead & envelopes	77.70		
Editor's supplies	12.13		
Editor's postage	4.52		
		$394.35	
Cash on hand Jan. 1, 1959			
The Hanover Bank	1234.38		
The Bowery Savings Bank	9373.67		
The Manhattan Savings Bank	6375.76		
	16983.81		
Outstanding checks	77.00		
		16906.81	
		$17301.16	$17301.16

Tenth TAPPI Testing Conference

The 10th TAPPI Testing Conference will be held at the

Front row, left to right: F. E. Caskey, local arrangements, Morden Machines; C. S. Walseth, general chairman, Weyerhaeuser Timber Co.; P. M. Toppari, member of Western Subcommittee of Pulp Testing Committee, Rayonier, Inc.
Back row, left to right, Norval Magnusson, vice-chairman, Pacific Section of TAPPI, Puget Sound Pulp & Timber Co.; J. L. McClintock, publicity, Weyerhaeuser Timber Co.; H. T. Randles, St. Regis Paper Co.; E. A. Christopherson, chairman, Western Subcommittee Pulp Testing Committee, Scott Paper Co.

Multnomah Hotel, Portland, Ore., Aug. 17–21, 1959. C. S. Walseth, Weyerhaeuser Timber Co., Longview, Wash., general chairman of the conference, has announced that the general theme of the conference is "Pulp Testing," but that the program will include papers on all phases of testing involved in the pulp and paper industry.

Anyone wishing to offer or suggest a paper for the program should get in touch with the program chairman, S. M. Chapman, Pulp and Paper Research Institute of Canada, 3420 University St., Montreal, Que., or with TAPPI headquarters, 155 E. 44th St., New York, N. Y.

In addition to the technical sessions, meetings of all testing committees will be held during the conference, and delegates will have an opportunity to participate in several interesting field trips. On Monday, August 17 mill tours will be held at Crown Zellerbach Corp., Camas, Wash., and Weyerhaeuser Timber Co., Longview, Wash. On Friday, August 20, delegates will visit Crown Zellerbach's Clatsop Tree Farms on the Oregon coast.

The conference committee (see photo) hopes that many TAPPI members will combine this conference with their vacations. The scenery will be long remembered. This is Oregon's Centennial Year, which makes it an ideal time to visit Oregon and the Pacific Coast.

1959 TAPPI Medal Presentation

The twenty-seventh TAPPI medal was presented to K. O. Elderkin, president, Bowaters Research and Development, Inc., Calhoun, Tenn., at the annual luncheon of the Technical Association of the Pulp and Paper Industry, held at the Commodore Hotel, New York, N. Y. on Feb. 26, 1959.

G. W. E. Nicholson, president of the Tennessee River Paper Mills, New York, N. Y., made the presentation address on behalf of the Executive Committee of the Association. The remarks of Mr. Nicholson and Mr. Elderkin follow:

Remarks by G. W. E. Nicholson

President Harrison, honored guests, members of TAPPI, ladies, and gentlemen:

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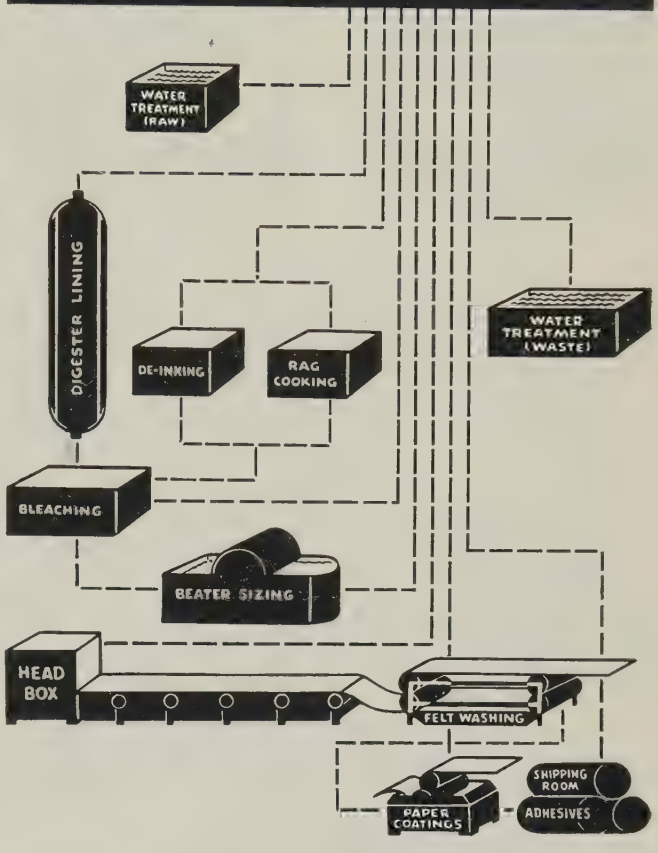

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- PQ silicate with the alum in the beater reduces beating time, produces a firmer sheet with improved finish.
- In the head box, PQ silicate increases fiber and filler retention on both cylinder and fourdrinier machines.

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#6-1 "PQ Soluble Silicates for the Pulp & Paper Industry"

#15-1 "Coating Paper Board with Sodium Silicate"

#52-19 "Treatment of Raw & Waste Waters with PQ Silicates"

#17-1 "PQ Soluble Silicates—Properties & Applications"

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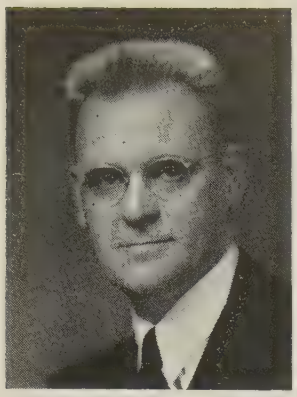
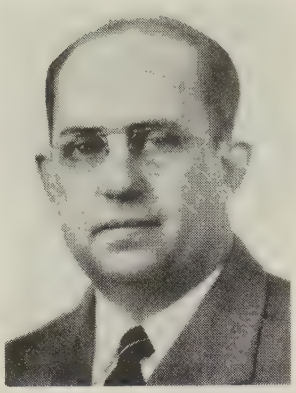


K. O. Elderkin



G. W. E. Nicholson

I am indeed very greatly honored by being asked to represent the Executive Committee and the members of TAPPI in presenting the TAPPI Gold Medal for the outstanding contribution to the technical advancement of the pulp and paper industry.

I am particularly happy and pleased to be participating on this very pleasant occasion as the medalist is a very good friend of mine. Knowing that the recipient is a very unpretentious and modest man, I am well aware that he wants me to be brief in the outline of his background and many accomplishments.

K. O. Elderkin is a native of Canada, born and brought up in Weymouth, Nova Scotia, where his father was a practicing country doctor. There is something about life in the Province of Nova Scotia which develops strength of character, integrity, and ability and which is so apparent when one reviews the greater roster of men from there who have been extremely successful in industry, commerce, and the arts in other sections of Canada as well as in the United States. It so happens that I can think of several prominent members of TAPPI who are natives of that province.

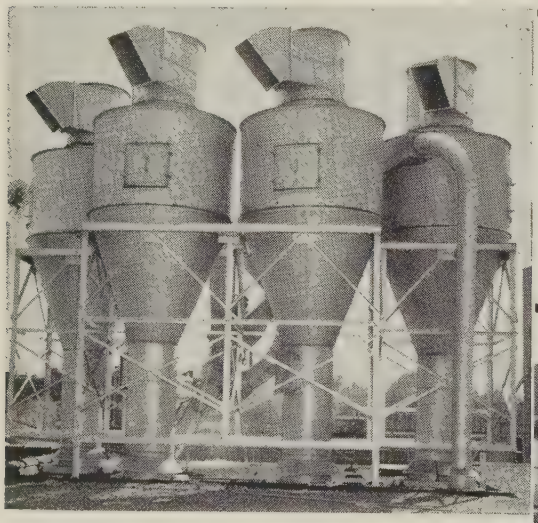
After graduating from high school in Weymouth, K. O. attended Mount Allison University at Sackville, N. B., during the following three years, at which time he completed the first part of his engineering course. He then entered McGill University but discontinued his course temporarily in order to serve his country in World War I by designing jigs and tools for the manufacture of shells at the Nova Scotia Steel & Coal Company in New Glasgow, N. S. The following year he enlisted as a mechanic in the Royal Flying Corps where he developed into an instructor in wireless operation as the authorities discovered he had experience in radio telegraphy.

When the war ended, he went back to McGill University and finished his engineering course, graduating in 1920 in mechanical engineering.

His first contact with industry after graduation was not with the paper industry but with the steel industry. He finally decided to locate a position in the newsprint industry and became a draughtsman during 1922 with the St. Lawrence Paper Mills Ltd. at Three Rivers, Que. This two machine newsprint mill was built at a record speed. The building was started on June 22 and paper was made the following January.

The following year K. O. became connected with Price Bros. at Kenogami where two new newsprint machines were being installed. During this period at Kenogami probably the most important event in K. O.'s life also took place—that is his marriage to Bess Lea.

In the spring of 1925 he moved again and became assistant chief engineer of the Abitibi Power and Paper Co. at Iroquois



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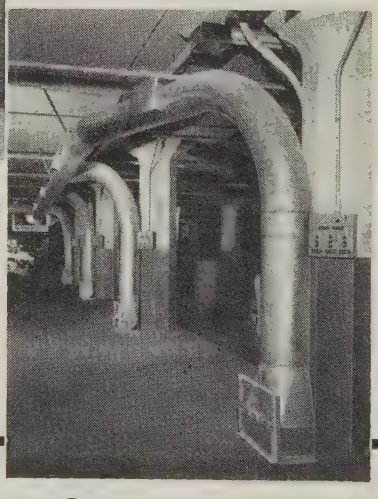

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Falls, Ont., where at that time one of the more well-known men from the early Canadian newsprint industry, R. A. MacInnis, was general manager. Harry Buncke was K. O.'s immediate superior. While in Iroquois Falls, K. O. together with Russell Stearns invented an arrangement for improved circulation of water in electric boilers which made it possible to use boilers up to 13,200 v. with good results. Improvements were also made under Harry Buncke's supervision on the thermojet steam compressor system allowing steam exhaust from the engines driving the paper machines to be collected in one header and then injected into the paper machine along with the make-up steam.

K. O. did not stay very long, however, at the Abitibi mill as he accepted a position as resident engineer in 1928 of the Mersey Paper Mill at Liverpool, N. S. During that period he worked with Col. Jones and the well-known consulting engineer, George F. Hardy, in the design of that mill.

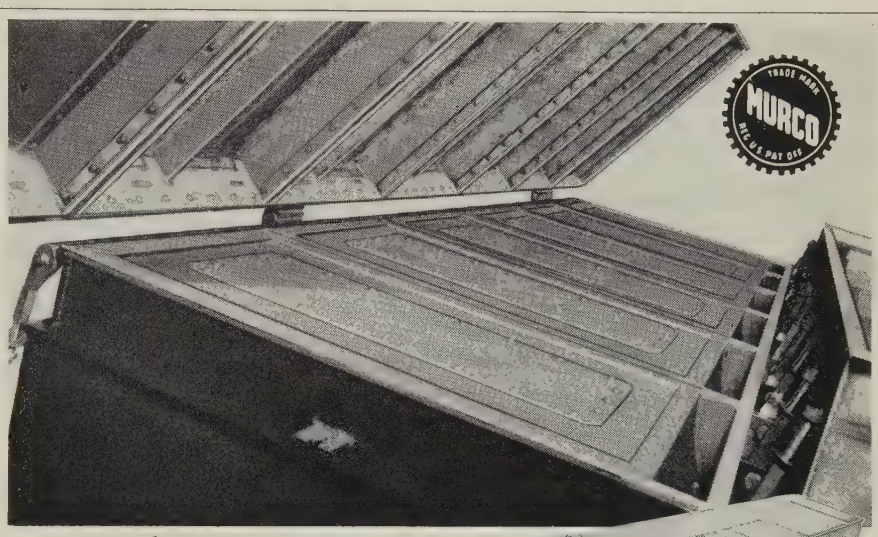
His next move was to Corner Brook, Newfoundland, where his job was as chief engineer and eventually manager during a period of almost eight years. During this period the Corner Brook mill and power plant was extended to a very great extent. Also, a number of new developments were worked out, such as a new design of draft tube and other improvements for the hydroelectric power plant.

Probably the most important move by K. O. was during 1939 when he became connected with The Crossett Co. in Crossett, Ark., and where during the early part of 1941 he took over the management of the plant. This was his first contact with kraft paper manufacture. During the Crossett period from 1939 to 1951 a great number of far-reaching developments took place, and probably the most important was the installation of the first vacuum pick-up to operate successfully on a kraft paper machine. This type of application was later applied by him in building the new newsprint mill at Calhoun, Tenn., which has made it possible to run the newsprint machines there over 2500 f.p.m.

In 1951, K. O. left Crossett to take charge of the design, construction, and the general management of the new Bowaters newsprint mill at Calhoun, Tenn. The first two paper machines started up in July and August of 1954 and these machines were the first ones built from the ground up to make newsprint using a vacuum pickup and they established new production records. Later on a third machine and just recently the fourth machine has been put into operation.

Among the many published features of the Calhoun mill, and probably the most outstanding one, is the underwater pulpwood storage. For some time before the Calhoun mill was built, the idea of storing pulpwood under water had been discussed by a group of kraft pulp and paper operators in the South but K. O. was the first one to put this idea into actual practice by designing the installation at Crossett as well as the one at Calhoun. This arrangement reduces the deterioration of the pulpwood and improves the quality of the finished product. The Calhoun newsprint mill has been recognized as one of the most efficient and successful pulp and paper operations in existence, for which K. O. should be given a great deal of credit.

The next move by our Gold Medalist was to give up the management of the Calhoun plant and head up a new organization, the Bowaters Research and Development Inc., with the primary object of taking over the design and construction work for Bowaters in North America, including the completion of the building of the newsprint mill at Calhoun, the building of a hardwood pulp mill there, and the building of the new 400-ton bleached kraft mill at Catawba, S. C. as well as the hardboard mill at the same site. This new assignment also includes studies and work at Corner Brook, Newfoundland, Liverpool, N. S., and other sections of the world where the world-wide Bowaters organization has interests.



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- All parts in contact with paper stock are stainless steel.
- For use in either Fourdrinier or cylinder machines . . . built for 8, 10, 12, and 14 plates.

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MURCO Stainless Steel Flat Screen is particularly adaptable for running different colors and grades of paper and board stock — any operation where cleaning and preparing the screen for the next run demands continuous operation without loss of time . . . plate section can be removed entirely and replaced easily instead of taking up the plates. Built for 8, 10, 12, and 14 plates, all parts in contact with the paper stock are stainless steel . . . its exclusive feature is the non-tip diaphragm actuating mechanism . . . diaphragms are designed to be easily removed without disturbing the other parts. It has eccentric drive mechanism — one drive unit for each four screen plates — eccentric and end bearings equipped with anti-friction self-aligning bearings. Its features of construction and quiet, free vibration operation with high production but low horse power requirements are surprising to mill men wherever the MURCO Stainless Steel Flat Screen is installed.

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WHILE IMPROVING QUALITY AND
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NO COOKING; is cold water soluble; can be added at beaters or pulpers.

REDUCES stock refining time.

PERMITS use of larger percentages of short fibre stock or clay. Improves drainage of sheet on wire. Allows machine speeds to be increased.

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INCREASES porosity, bulk and compressibility.

DECREASES hygroexpansitivity, curl, warp and two-sidedness.

WET STRENGTH obtainable by wetting any sheet containing #7 with borated water when half-way over dryer section. *Is also a NON-TOXIC flocculant; 4 ppm flocs and settles solids.* LCL price is UNDER 35¢ lb.

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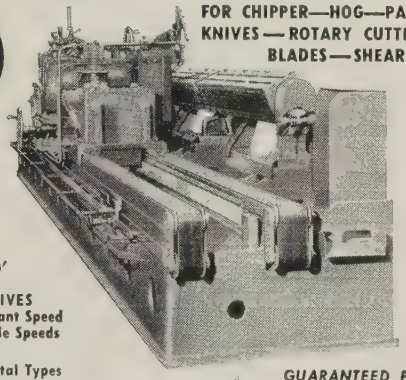
FOR CHIPPER—HOG—PAPER—VENEER KNIVES — ROTARY CUTTERS — DOCTOR BLADES — SHEAR BLADES, ETC



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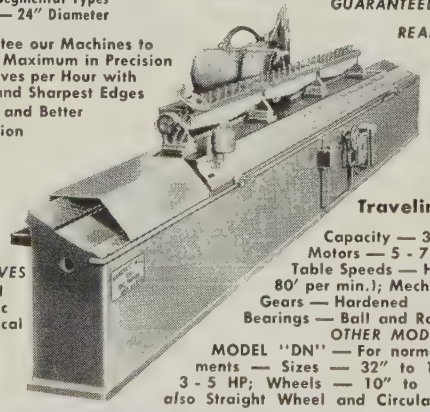

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TABLE DRIVES
Mechanical
Hydraulic
Electrical

HANCHETT MANUFACTURING COMPANY
Main Plant
BIG RAPIDS, MICHIGAN
West Coast
PORTLAND 1, OREGON

K. O. has been very active in the TAPPI organization over the years and has served on the Executive Committee as well as having been vice-president and president of the organization. He also spearheaded the reorganization of TAPPI in recent years.

He went to Austria in 1950 as one of three consultants to the Economic Cooperation Administration advising upon a program for the rehabilitation of the Austrian paper industry.

He is also an active member of the Engineering Institute of Canada and the Technical Section of the Pulp and Paper Association of Canada. Also he has been very active over the years and has played a great role in the development of the pulp and paper industry on the American Continent.

It is now my great pleasure and privilege, acting on behalf of the members and Executive Committee of TAPPI, to present to you, Karl O. Elderkin, the TAPPI Gold Medal for the year 1959 in recognition of your very active and useful life devoted to the development and improvement of the pulp and paper industry.

Response by K. O. Elderkin

Mr. President, fellow members of TAPPI, ladies and gentlemen, I cannot conceive of a higher honor which anyone in our industry could receive than the award of this medal. I appreciate better than most people just what this medal means; because I have worked closely with the TAPPI management, and I have in the past had a part in the selection of previous medalists so I know that they are very carefully selected. I am also particularly happy to have my old friend Gunnar Nicholson make the presentation. I had the honor a few years ago to present the TAPPI medal to him, and I consider him a far more worthy recipient than the present winner. I am therefore deeply grateful to TAPPI for this high honor and from the bottom of my heart I thank you.

It has been customary for medal recipients to bring a "message" to TAPPI. I am not going to depart from precedent, but my message will be in the nature of a reminder and will be very fundamental, and I trust not too long drawn out.

I want to remind you of what seems to me to be a self-evident truth; namely, that we as a nation can only *have* what we produce or what we can get in exchange for what we produce. Or stated another way production is the key to a higher material standard of living; or it may even be simplified still further by simply saying: "We can't get something for nothing"—although there are apparently many people who still think they can. It is strange how many people ignore this simple fact of life.

However, we had in our industry at one time a labor leader who understood this simple fact. I don't remember how he phrased the policy under which he operated, but it might have been phrased like this: "We will help our employers in every reasonable way to make more money for our companies, but we will make sure we get our share of it." I can't find anything wrong with that policy. It would be good if more labor leaders adopted it, and it would not be a bad policy for the individual members of TAPPI either. It recognized that greater production was the only means of raising the living standards of men—without simply taking from others.

It is pretty obvious that men are not going to work harder to raise their standard of living—the trend is the other way—and rightly so; because of what use is technical progress if it does not lighten man's labor, shorten his hours of work, and lengthen his leisure time to enjoy the fruits of greater production—but remember, the greater production must be there before it can be enjoyed.

Greater production per man comes only in one way—the way it always has come—through the application of science, the spending of capital money by efficient management for better and better methods, and machinery developed through science by people like you.

You have been trained through your own volition to accept the responsibility of improving the material well being of man—that is your opportunity and your duty.

There are those who deplore that man's spiritual development is not keeping pace with the developments of science. If this is so, which I doubt, then I think it is high time that those who have been trained in the development of man's spiritual side should get to work and strive as hard as we, who have been trained in the job of increasing man's material well being.

You people in TAPPI have a wonderful opportunity to further man's well being. Your industry produces each year over 400 lb. of the necessities of life for each member of our society which is a sizable proportion of his wants. By improving the quality of those commodities, finding new uses for paper and reducing the cost, you can make a tremendous contribution to better living for all.

Let us look at some of the details by which this end result will be obtained through your efforts. Our principal raw material—wood—is just beginning to receive the benefits of scientific investigation. Our foresters have shown us how to grow more trees faster, and our loggers have greatly improved cutting and transportation; but little has been done about the quality of the tree itself until the rather recent onslaught (in this country at least) of the forest geneticist. I believe these fellows will produce trees with better fibers designed for papermaking and will show us how to grow them faster.

More work has been done on new and better methods of pulping in the last few years than in all our history. Out of this must come continuous cooking methods which are much better than our present batch or continuous methods and which will produce better and cheaper pulp. New raw materials may be found, but up to now I am betting on wood.

Advances in the refining and treatment of pulp are continually being made.

We have been improving the fourdrinier for better than a hundred years, and I believe this veteran of our industry has been developed about as far as it will be. Experiments with other types of forming machines are being carried out both in this country and abroad which are sure to open up a complete new vista for high-speed papermaking.

The press section on high-speed machines has undergone improvements, and these improvements will be continued if you people do your job.

What justification is there, other than our own ignorance, for a drying section of thousands of tons of cast iron to contain a few pounds of paper during the drying process—surely there must be a better way. Developments are already afoot which may reduce the weight to a quarter or less of the present weight, and search for better methods of drying paper must continue.

The calender stack has been refined and improved over the years but not basically changed. In high-speed machines, calender stacks are a pain in the neck, and we must have something better. It's up to you to produce them.

The modern paper reel is a pretty fair piece of machinery, but it still has an open draw into it.

The winding operation should be unnecessary and could be made so, if the rest of the operation were more nearly perfect.

Finishing machinery, I think, is generally more advanced than papermaking machinery, and improvements are rapidly being made, but our finishing and converting plants still use too much labor.

Automatic operation is scoring advances with each new mill and in many old ones. Anyone who has seen the wood handling in the grinder room at one of the mills in the Northwest has seen a very near approach to a push-button grinder room. With continuous cooking, will come automatic cooking. The push-button machine isn't so far away either, as some of our newest ones demonstrate.

I have been talking about improvements to present machin-

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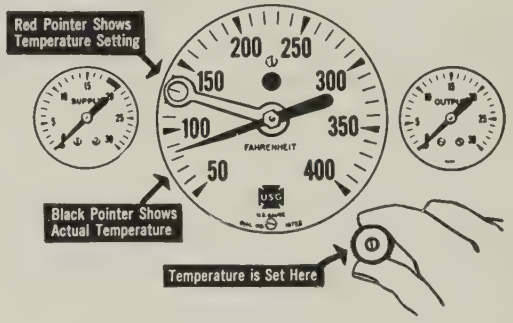
New control maintains best temperature in each wet end dryer



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Moisture Control Systems
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ery. I fully believe that before long we will see the beginnings of entirely new kinds of papermaking machinery, new processes, new treating methods and materials, and entirely new uses. Such a prospect should fire the enthusiasm of any technical man.

I have worked in this industry for 36 years, and there has never been a time when it did not offer to me opportunities and a challenge sufficient to keep up my enthusiasm and my interest in my job, and the rewards have been commensurate —what more can any industry offer its workmen!

My message condensed is therefore to remind you never to forget that you can't get something for nothing unless you take it from someone else. That our material welfare will depend only on increased production. That increased production can *only* be achieved by the application of better machinery and better methods applied by management with the help of technical brains and by the expenditure of capitol money which must come from earnings.

You in this industry are living now in a golden age of scientific progress which will provide all of you with opportunities for constructive work and the satisfaction of a job well done, and that, I think you will admit, will go a long way toward contributing to your future happiness and well being.

Paper Industry Programs for College Students

It was "Clemson College Day" December 18 as the Champion Paper and Fibre Co.'s Carolina Division at Canton, N. C., was host to 70 student members of the American Society of Mechanical Engineers and the American Institute of Electrical Engineers. The program was arranged as part of the TAPPI program to acquaint engineering students with the pulp and paper industry and its career opportunities.

The Clemson students motored up from South Carolina early in the morning and assembled in the Champion YMCA gym for a welcome by J. E. Williamson, Champion's assistant manager of personnel administration, and a showing of the company's movie, "Paper Work." The group was then given a description of the nation's pulp and paper industry in a talk by J. E. Wilkinson, manager of the Carolina Division's process controls department and an active TAPPI member. The future engineers were then conducted on a tour of the Champion mill, with experienced engineers and technical personnel serving as guides, and were guests of the company for luncheon.

In addition to Clemson and the 11 other schools whose paper industry programs were listed in the January *Tappi*, 23 college chemistry and engineering groups sponsored paper industry lectures by TAPPI members during February and March. These were:

Berea College, Berea, Ky., ACS Student Affiliate Chapter. February 16. Speaker: H. R. Joiner, Champion Paper & Fibre Co., Hamilton, Ohio.

Bucknell University, Lewisburg, Pa., ACS Student Affiliate Chapter. February 17. Speaker: E. E. Rodabaugh, New York & Pennsylvania Co., Lock Haven, Pa.

Long Island University, Brooklyn, N. Y., ACS Student Affiliate Chapter. February 18. Speaker: P. E. Nethercut, TAPPI, New York, N. Y.

University of Michigan, Ann Arbor, Mich. AIChE Student Chapter. February 18. Speaker: E. E. Stephenson, Sutherland Paper Co., Kalamazoo, Mich.

Lehigh University, Bethlehem, Pa., ACS Student Affiliate Chapter. February 19. Speaker: P. E. Nethercut, TAPPI, New York, N. Y.

Stanford University, Palo Alto, Calif., AIChE Student Chapter. February 24. Speaker: D. F. Church, Crown Zellerbach Corp., Antioch, Calif.

Canisius College, Buffalo, N. Y., ACS Student Affiliate Chapter. March 2. Speaker: R. H. Zinsmeister, Kimberly-Clark Corp., Niagara Falls, N. Y.

University of Louisville, Louisville, Ky., AIChE Student Chapter. March 5. Speaker: N. Balfour, Beveridge Paper Co., Indianapolis, Ind.

Clemson College ASME and AIEE tour through Champion Paper & Fibre Co., Canton, N. C.

Mississippi State College, State College, Miss., AIChE Student Chapter. March 5. Speaker: R. R. Fuller, Gulf States Paper Corp., Tuscaloosa, Ala.

City College of New York, New York, N. Y., ACS Student Affiliate Chapter. March 5. Speaker: P. E. Nethercut, TAPPI, New York, N. Y.

Georgia Institute of Technology, Atlanta, Ga., AIChE Student Chapter. March 10. Speaker: R. R. Chase, Union Bag-Camp Paper Co., Savannah, Ga.

Ohio University, Athens, Ohio, ACS Student Affiliate Chapter. March 10. Speaker: H. A. Smith, The Mead Corp., Chillicothe, Ohio.

Tufts University, Medford, Mass., AIChE Student Chapter. March 10. Speaker: J. W. Field, TAPPI, New York, N. Y.

Boston University, Boston, Mass., ACS Student Affiliate Chapter. March 10. Speaker: J. W. Field, TAPPI, New York, N. Y.

University of New Hampshire, Durham, N. H., AIChE Student Chapter. March 11. Speaker: J. W. Field, TAPPI, New York, N. Y.

University of Toledo, Toledo, Ohio, AIChE Student Chapter. March 12. Speaker: W. C. Lunsford, Consolidated Paper Co., Monroe, Mich.

Boston College, Boston, Mass., ACS Student Affiliate Chapter. March 12. Speaker: J. W. Field, TAPPI, New York, N. Y.

City College of New York, New York, N. Y., AIChE Student Chapter. March 12. Speaker: P. E. Nethercut, TAPPI, New York, N. Y.

Southwestern Louisiana Institute, Lafayette, La., ACS Student Affiliate Chapter. March 16. Speaker: J. J. Goss, Crown Zellerbach Co., Bogalusa, La.

Purdue University, Lafayette, Ind., ACS Student Affiliate Chapter. March 17. Speaker: N. Balfour, Beveridge Paper Co., Indianapolis, Ind.

Franklin and Marshall College, Lancaster, Pa., ACS Student Affiliate Chapter. March 17. Speaker: B. C. Miller, P. H. Glatfelter Co., Spring Grove, Pa.

University of Rhode Island, Kingston, R. I., AIChE Student Chapter. March 19. Speaker: H. W. Verseput, Continental Can Co., Uncasville, Conn.

Washington University, St. Louis, Mo., ACS Student Affiliate Chapter. March 25. Speaker: J. P. Casey, A. E. Staley Mfg. Co., Decatur, Ill.

Errata

In the November, 1958, issue of *Tappi* there are two papers by Alexander Meller, both relevant to wet strength, "The Effect on Paper Wet Strength of Oxidation of the Carbohydrate Polymers in Wood Pulps," page 679, and "The Effect on Paper Wet Strength of Oxidized Starches as Beater Additives," page 684. Each paper has one figure but through an editorial error they were interchanged. Figure 1 of the first paper should be in the second and Fig. 1 of the second should be in the first.

In the paper "The Nonglucose Sugar Units in Cellulose Acetate" by Kei Matsuzaki and Kyle Ward, Jr., which appeared in *Tappi* 41, No. 8: 396–402 (Aug., 1958), the sentence on page 397, beginning 9 lines above Fig. 1 should read as follows: "As $r=0.878$ for the 5% level ($N = 5$), the result suggests strong correlation between the anomalous viscosity and content of mannose units." The next sentence should be deleted.

TAPPI ANNUAL REPORT—1958

Report of the Secretary

The year 1958 of the Technical Association of the Pulp and Paper Industry was featured by a steady growth in membership and a sustained interest in divisional and section activities.

Membership

There were 971 individual members elected in 1958, 423 members resigned or were dropped from the membership. On Dec. 31, 1958, the total individual membership was 9326.

There were 11 corporate members elected in 1958: 12 corporate members resigned or were lost through company mergers. The corporate membership on Dec. 31, 1958, was 271.

The following companies became corporate members in 1958:

Adamjee Industries Ltd., Karachi, Pakistan
Ambrogio Binda SpA, Cartiere, Milano, Italy
Angel & Co., Inc., H. Reeve, New York, N. Y.
Aschaffenburger Zellstoffwerke A/G, Redenfelden/Obb., Germany
Bank Industri Negara, Djakarta, Indonesia
Cia. de Celulose do Ultramar Portogues, Lisboa, Portugal
Cia. Gen. Papelera de Buenos Aires S. A., Buenos Aires, Argentina
Club dei Cartai, Milano, Italy
Continental Can Co., New York, N. Y.
Groveton Paper Co., Groveton, N. H.
Heinr. Aug. Schoeller & Sons, Duren, Rhld., Germany

There were 14 sustaining members elected in 1958: 21 sustaining members resigned. The sustaining membership on Dec. 31, 1958, was 274.

The following companies became sustaining members in 1958:

American SF Products, Inc., New York, N. Y.
Archer-Daniels-Midland Co., Minneapolis, Minn.
Fuller, H. B. Co., St. Paul, Minn.
Gardner Laboratory, Inc., Bethesda, Md.
General Mills, Inc., Minneapolis, Minn.
Hodag Chemical Corp., Chicago, Ill.
I-T-E Circuit Breaker Co., Philadelphia, Pa.
Jenssen Co., Inc., G. D. Massena, N. Y.
Munro & Sons, Inc., Hugh F., Philadelphia, Pa.
Rader Pneumatics, Inc., Portland, Ore.
Red Jacket Co., Carnegie, Pa.
Square D Co., E. C. & M. Div., Cleveland, Ohio
Tidland Machine Co., Camas, Wash.
Wica Chemicals, Inc., Charlotte, N. C.

Necrology

The association lost the following members through death in 1958:

Harry A. Bachmann, Dairy-Pak, Inc., Cleveland, Ohio
LeRoy J. Bauer, Bauer Bros. Co., Springfield, Ohio
Arthur P. Bellinghausen, Kimberly-Clark Corp., Neenah, Wis.
George E. Chamberlin, Minnesota & Ontario Paper Co., Minneapolis, Minn.
Daniel L. Clear, Moraine Paper Co., W. Carrollton, Ohio
J. Franklin Crook, John W. Bolton & Sons, Inc., Lawrence, Mass.
Fred A. Dieckbrader, Hinde & Dauch Paper Co. of Canada, Toronto Ont., Canada
Hugo Elling, Vereingte Glanztoff-Fabriken A/G, Wuppertal, Germany
Edward W. Engel, Industrial Tape Corp., New Brunswick, N. J.
Foskett H. Godfrey, A. E. Broughton & Co., Glens Falls, N. Y.
Samuel S. Gutkin, Cargill, Inc., New York, N. Y.
Ralph M. Kingsbury, U. S. Forest Products Laboratory, Madison, Wis.
Robert E. Knox, Knox & Schneider, Chicago, Ill.
Lloyd Lang, Consultant, De Pere, Wis.
Richard Theodor Lang, J. M. Voith, G.m.b.H., Geidenheim (Brenz) Germany
John A. MacArthur, MacArthur, Malkin & Co., Montreal, P. Q., Canada
Alfred H. Montville, The Black-Clawson Co., Atlanta, Ga.
C. Noble Mull, The Mead Corp., Chillicothe, Ohio
Ralph T. Nazzaro, Westfield River Paper Co., Russell, Mass.
George M. Norton, George M. Norton & Sons, Henniker, H. H.
Robert C. Palmer, Consulting Engineer, Pensacola, Fla.
James S. Snyder, J. & J. Rogers Co., Au Sable Forks, N. Y.
Georges Soules, Ets. Drouet, Paris, France
Stephen A. Staege, The Black-Clawson Co., Hamilton, Ohio
Lester M. Start, Jr., Sales Engineer, Worcester, Mass.
R. W. Stephenson, Kirby Chemical Co., Severn, N. C.
Edward J. Sullivan, The Bowater Paper Co., Inc., New York, N. Y.
Edwin Sutermeister, Retired, Westbrook, Me.
George H. Tomlinson, The Howard Smith Paper Mills Ltd., Montreal, Que., Can.
Robert M. True, General Dyestuff Div., San Francisco, Calif.
Wm. Bond Wheelwright, Advertising Counsellor & Writer, Cambridge, Mass.
Frederick Wierk, Pulp & Paper Consultant, Jacksonville, Fla.

Publications of the Association

Tappi

Tappi, the monthly magazine of the Association, completed its tenth successful year of publication. In 1958 there were 816 pages published in the technical section. This compares with 994 pages in 1957 and 896 pages published in 1956. The total number of pages published was 3398 in contrast with 3588 in 1957. The circulation of the magazine made a substantial increase. There were 1094 pages of advertising run in 1958 in contrast to 1255 pages in 1957 and 1155 pages in 1956. This 13% drop was in line with the experience of the business paper industry during the same period.

Bibliography of Papermaking and U. S. Patents

Two cloth-bound issues of the Bibliography of Papermaking and U. S. Patents were issued in 1958. These books covered the literature for 1956 and 1957. They were prepared by Jack Weiner and his associates, at The Institute of Paper Chemistry.

Monographs

Two monographs were published in 1958. TAPPI Monograph No. 19 "Paper Loading Materials" was sponsored by the Preparation of Papermaking Materials Committee. Monograph No. 20 "Paper Coating Pigments" was sponsored by the Coating Committee.

Special Reports

A total of five Special Reports were prepared and distributed during 1958. These were:

No. 422 Cyclical Fourdrinier Wet End Variations
No. 423 Groundwood Mill Quality Control
No. 424 Power Requirements of Paper Machines
No. 425 Size Press Operation
No. 426 Mill Operating Experience with Grounded and Ungrounded Low-Voltage Power Distribution Systems

Standard and Suggested Methods

During 1958 the following five new methods, nine revised methods, and nine corrected methods were prepared for publication and general mailing in loose-leaf form.

T 203 m-58	Alpha, Beta, and Gamma-Cellulose in Pulp
T 205 m-58	Forming Handsheets for Physical Tests of Pulp
T 210 m-58	Weighing, Sampling, and Testing Pulp for Moisture
T 218 m-58	Forming Handsheets for Optical Tests of Pulp
T 223 m-58	Pentosans in Pulp
T 228-m-57	Bacteriological Examination of Pulp
T 231 sm-58	Zero-Span Breaking Length of Pulp
T 232 sm-58	Fiber Length of Pulp by Projection
T 234 sm-58	Coarseness of Pulp Fibers by Projection
T 235 m-58	Solubility of Pulp in Cold Sodium Hydroxide
T 441 m-58	Water Absorptiveness of Nonbibulous Paper and Paperboard (Cobb Test)
T 445 sm-57	Identification of Specks and Spots in Paper
T 449 m-57	Bacteriological Examination of Paper and Paperboard
T 484 m-58	Moisture in Paper and Paperboard by Toluene Distillation
T 606 m-58	Preparation of Liquid Analytical Reagents
T 627 m-58	Determination of Titanium Dioxide
T 631 m-57	Bacteriological Examination of Process Water and Slush Pulp
T 636 m-57	Oil Content of Petroleum Waxes
T 639 sm-58	Needle Penetration of Petroleum Waxes
T 644 m-58	Tensile Strength of Paraffin Wax
T 652 sm-57	Blocking Range of Paraffin Wax
T 653 sm-58	Specular Gloss of Waxed Paper at 20°
T 654 sm-58	Odor of Petroleum Wax

TAPPI Data Sheets

The following Data Sheets were published in *Tappi* during 1958.

No. 197.	Viscosities of Various Spent Liquors at 76.5°F.
No. 198.	Boiling Point Rise of Spent Liquors
No. 199.	Viscosity of a Neutral Sulphite Spent Liquor
No. 200.	Specific Gravity of a Neutral Sulphite Spent Liquor
No. 201.	Equilibrium Solubility of Sodium Chloride in Concentrated Sodium Hydroxide
No. 202.	Approximate Requirements for Electric Power in Pulp Bleaching

TAPPI Medal Award

The 26th TAPPI Medal for outstanding contributions to the technical advancement of the pulp and paper industry was awarded to Walter H. Swanson, vice-president in charge of research and development of the Kimberly-Clark Corp., Neenah, Wis. The presentation was made by Roy P. Whitney of The Institute of Paper Chemistry, Appleton, Wis.

Employment

The employment service section of *Tappi* reflects, to some extent, the supply and demand for technically trained men. During 1958, 83 companies advertised for one or more men. There were 53 requests for positions by individuals. In 1957 there were 113 requests by companies and 51 requests from individuals for new positions.

Local Sections

One new section was chartered in 1958. This was the Gulf Coast Section. It will receive its charter at a ceremonial to be held in New Orleans, La., in May, 1959.

The chairmen of Local Sections elected in 1958 were:

Pacific—Paul S. Billington, Weyerhaeuser Timber Co., Longview, Wash.
Golden Gate District—Wayne Kuefner, The Flintkote Co., San Leandro, Calif.
Lake States—Walter J. Bublitz, Kimberly-Clark Corp., Neenah, Wis.
Delaware Valley—D. C. Kane, Hercules Powder Co., Wilmington, Del.
Kalamazoo Valley—Edward E. Stephenson, Jr., The Sutherland Paper Co., Kalamazoo, Mich.
New England—E. Whitman Strecker, Esleek Mfg. Co., Turners Falls, Mass.
Eastern District (N. E.)—Charles H. Horch, Mead Corp., Leominster, Mass.
Ohio—E. William Petrick, Howard Paper Mills, Dayton, Ohio
Indiana District—H. O. Ware, Beveridge Paper Co., Indianapolis, Ind.
Empire State—J. W. Morrow, Newton Falls Paper Co., Newton Falls, N. Y.
Maine-New Hampshire—Andrew J. Chase, University of Maine Orono, Me.
Chicago—Melvin W. Snover, Hollingsworth & Vose Co., Chicago, Ill.
St. Louis District—James R. Lyon, Alton Box Board Co., Alton, Ill.
Lake Erie—Dennis E. Heindel, General Carton Co., Cleveland, Ohio
Southeastern—R. R. Chase, Union Bag & Paper Co., Savannah, Ga.
Gulf Coast—J. E. Doyle, St. Regis Paper Co., Pensacola, Fla.
Virginia-Carolina—Robert E. Bowen, Continental Can Co., Hopewell, Va.

Local Sections Operations Committee

The second meeting of the Local Sections Operations Committee was held on Oct. 16, 1958, at the Engineering and Scientific Societies Center in Cleveland, Ohio. This committee is composed of the chairmen of the local sections, the Executive Secretary of the Association serving as chairman.

Eight chairmen or alternates were present. Chairmen present were: Norman S. Lea (Pacific); C. F. Ackerman (Delaware Valley); Malcolm J. Lyon (Ohio); Kaz Horita (Chicago); Grant G. Cole (Empire State); R. J. Martin (Maine-New Hampshire); Charles A. Markee (Lake Erie); and Roy L. Miller (vice-chairman of the Southeastern Section representing W. C. Chapman, chairman).

The report of the meeting follows:

R. G. Macdonald, chairman, called the meeting to order at 10:15 a.m.

The "Manual for the Guidance of Local Section Officers" was discussed briefly. The group agreed that this manual had been very helpful. It may be revised one or two years from now if necessary. Mr. Stephenson suggested that the manual be included in the Year Book. Since TAPPI is attempting to reduce the volume of material in the Year Book, however, any future version of the manual might be better published in *Tappi*.

The purpose of Local Section Operations Committee meetings was reviewed. Several members urged that vice-chairmen or other junior officers of the local sections should be invited to future meetings. This would aid in training these men to become local section chairmen and would provide continuity of leadership in the event that a chairman had to be replaced during his term. It was also agreed that all district chairmen should be invited. On such matters as approving a request for a local section charter, however, only the local section chairmen would be considered voting members of the Local Section Operations Committee.

Mr. Macdonald urged the local section chairmen to make full use of *Tappi* in publicizing their meetings. Such publicity before and after the meeting is of great benefit to the local sections. Since many speakers do not speak from manuscripts, it may be desirable to use tape recorders at the meetings. In such cases, however, it is customary to submit a transcript of the speech to the speaker for his approval before publication. Mr. Macdonald stressed the importance of assigning to a specific local section officer the responsibility of obtaining a manuscript or recording of the speech. Mr. Macdonald noted that a local section has the authority to give a paper presented at its meeting to other magazines if it wishes.

The printed instructions available for speakers at TAPPI conferences ("Your Audience Has High Hopes" and "Suggestions for Your TAPPI Talk") were distributed for inspection.

Report of Income and Expenses—1958
Technical Association of the Pulp and Paper Industry

	Total budget, 1958	*Actual, 1958*
Summary		
Income	593,000	569,880.01
Expenses		
Administrative	118,900	107,924.66
Technical activity	294,650	316,068.96
Local section activity	27,430	11,351.02
Tappi magazine	232,100	212,614.76
	673,080	647,959.40
Operating balance or (deficit)	(80,080)	(78,079.39)
Expenses		
Administrative		
Salaries	33,000	28,549.50
Consulting fees	6,000	5,100.00
Retirement fund	6,300	5,668.95
Audit and bookkeeping	3,300	3,300.00
Rent and electricity	19,200	19,191.95
Postage	8,500	7,781.80
Stationery, supplies & equipment	12,000	13,000.41
Telephone & telegraph	3,500	3,400.77
Travel	4,000	2,134.36
Year Book	18,000	15,272.19
Dues and subscriptions	300	327.65
Payroll taxes	2,400	1,709.99
Insurance	200	329.67
Miscellaneous	1,200	1,999.85
Stenographic services	1,000	157.57
	118,900	107,924.66
Technical activity		
Salaries	72,900	71,568.50
Retirement fund	3,800	6,203.49
Annual meeting & conferences	49,000	48,184.27
Committee meetings	3,000	788.19
Bibliography preparation	7,500	7,500.00
Bibliography publication	40,000	57,321.70
Standards preparation	3,500	13,292.60
Technical publications	37,000	29,847.55
Research projects	60,000	64,460.96
Travel	10,000	9,612.88
Dues, The Institute of Paper Chemistry	2,000	2,000.00
Miscellaneous	150	61.98
College Text Book	5,800	5,226.84
	294,650	316,068.96
Local Section Activity		
Salaries	10,500	4,095.00
Retirement fund	2,430	600.00
Rebates	3,000	2,486.25
Travel	7,000	2,632.89
Meeting expense	4,500	1,536.88
	27,430	11,351.02
Tappi Magazine		
Salaries	37,300	33,917.00
Retirement fund	12,200	3,319.81
Publications and printing	180,000	173,978.34
Travel	2,500	1,307.94
Miscellaneous	100	91.67
	232,100	212,614.76

Several local section chairmen requested copies for their speakers.

Local Section Dues

The Ohio Section is the only local section which has bonded its treasurer. This was done largely because he also served as treasurer for the 1958 Deinking Conference. According to Mr. Petrich the annual cost for a $3000 fidelity bond was $10; it provided protection against loss by embezzlement or theft. Since the insurance company required salary information and character references, there was some feeling that bonding was unnecessary. Conceivably theft insurance, which does not require such careful scrutiny, would be adequate and less expensive.

The dues and meal charges of the various local sections were compared. These are listed in the table below:

	Annual dues	*Meal charges*
Lake Erie	$5.00	$4.50
Delaware Valley	3.00	3.50
Lake States	1.00	2.50–4.00
Kalamazoo Valley	2.00	2.75–4.00
Gulf Coast	5.00	5.00–6.00 (includes cocktails)
Empire State	1.50 (TAPPI)	3.50–4.50
	3.00 (non-TAPPI)	3.50–4.50
Ohio	1.50 (TAPPI)	4.00
	2.00 (non-TAPPI)	4.00
Indiana	2.00	3.75

Local Section policies regarding cocktail parties were compared. The Southeastern Section prefers a cocktail party financed by registration fees to prevent members meeting in small groups in hotel rooms. Most other sections have a cash bar. The Lake States Section has one social meeting annually and allows suppliers to pay for that cocktail party. Several chairmen reported that they were reluctant to have suppliers sponsor cocktail parties unless permission was first obtained from the local section executive committee. Mr. Bublitz asked how other local sections handled drinking when high school science students attended the meetings. One section invites the students to the meeting after the dinner but not to the dinner itself. At the New England Section, on the other hand, the meeting is held at 4:00 to 6:00 p.m.; in that way the students leave before the dinner and evening program begin.

Joint Meetings

Mr. Stephenson commented on the competition for members between the local sections of various societies in the Kalamazoo area, and the overlapping memberships of these groups. Where such societies have broad interests in common, joint meetings have been held. Last year the section met with the Superintendents Association; it has also sponsored joint programs with the American Society for Quality Control and the National Association of Accountants. It was agreed, however, that planning and staging such meetings should be a joint undertaking, so that the program will be attractive to the members of both associations.

Section Rebates

The mechanics of requesting rebates for TAPPI members belonging to local sections was reviewed. To facilitate the processing of these requests each local section treasurer should forward the following information to the headquarters office: a complete mailing list, a financial statement, and a list of TAPPI members who have paid dues to the local section. In the case of a TAPPI member who pay dues to several local sections, the rebate will be given to the section in which he lives, provided of course that he is a dues-paying member of that section. Mr. Macdonald described the practice of the Pacific Section, which does not charge local section dues to TAPPI members. In this case a rebate is given only for those TAPPI members who have indicated their interest in the Pacific Section by attending at least two of its meetings that year.

Mr. Petrich asked what other funds were available to assist local sections. Mr. Macdonald explained that $4500 had been made available for this purpose in the 1958 budget. Usually half of this was allocated for the Pacific Section Seminar, leaving roughly $2200 to be distributed among the other sections. This year, however, the Pacific Section had invited Dr. Eyring of Utah to be its guest speaker, and his travel expenses had been far less than those of foreign speakers in past years. Consequently, most of the allocation has been unspent. It was agreed that requests for financial assistance should be approved by the TAPPI office before firm commitments are made with speakers requiring such reimbursements. The payment of an honorarium to a speaker is discouraged, if the local section expects to request TAPPI funds for this purpose.

Gulf Coast Section

Mr. Macdonald distributed copies of a petition for a local section charter by the Gulf Coast District of the Southeastern Section. He explained that the Local Section Operations Committee was responsible for approving or rejecting this proposal, and that the Executive Committee would adopt whatever recommendations were made by this committee. Mr. Doyle reviewed the history of the Gulf Coast District and reported that the Southeastern Section's Executive Committee had given its endorsement to the proposal. Mr. Stephenson moved that a local section charter be granted to the Gulf Coast District. Mr. Bublitz seconded the motion. It was passed unanimously.

Local Section Manpower Activities

Mr. Macdonald distributed copies of replies to a questionnaire on Local Section manpower activities. These replies had been received from the Local Section chairmen last spring. The education programs of the Ohio Section, the Maine-New Hampshire Section, and the Kalamazoo Valley Section were described, and Mr. Nethercut commented briefly on the projects of various TAPPI technical committees working in this field. A lengthy discussion followed on whether or not such programs were a major or minor responsibility of the local sections. It was suggested that the headquarters staff should provide over-all leadership in such activities and should supply printed material, posters, speech outlines, and demonstration kits to the local sections interested in working with local high schools and colleges.

Means of improving local section programs were discussed next. Mr. Stephenson suggested that TAPPI might encourage seminar sessions in which instructive papers by qualified experts are followed by a round-table discussion. He proposed that a team of such experts might speak at meetings of several local sections on subjects of wide interest. In this way several local sections could benefit from one program.

Mr. Doyle asked if a list of qualified speakers could be prepared by the headquarters staff to aid local section program chairmen. This list would include such information as the speaker's name, the subject of his paper, and whether or not he had presented this paper at other local section meetings or TAPPI conferences.

Improved liaison between various local sections was discussed briefly. Mr. Kroeschell noted that men living in one section might be encouraged to attend meetings in a nearby local section, if the local sections publicized each other's programs more effectively. Salesmen who travel in several local section areas would be particularly helpful in publicizing these meetings.

Italian Group

Mr. Macdonald described the recent activities and future aspirations of the Association of Italian Members of TAPPI. A recent letter from Dr. Piero Bersano, chairman of this group, was read. Several members commented enthusiastically on the advantages to TAPPI of establishing a local section overseas, provided of course that this group satisfied the requirements for a local section charter. Mr. Stephenson noted that such a gesture of international cooperation should create considerable good will and might therefore have the enthusiastic endorsement of the State Department.

Local Section Awards Competition

Several chairmen described the award competitions in their local sections. In the last few years it has become increasingly difficult to obtain papers for these contests. As a result several sections have modified their requirements. The Southeastern Section permits a contestant to present his paper at any time during the year. The Lake States Section now permits a paper on any subject of interest to the local section, rather than limiting the papers to subjects involving original research. The Ohio Section has discontinued its contest this year. The Delaware Valley Section dropped its contest last year but plans to resume it again this year. Several chairmen wondered whether the contests were worth the effort to stage them. It was suggested that the contests might be held every other year, or that the men for whom the contests have been named might be commemorated by holding an annual meeting, rather than a contest, in their memory.

The role of the Joint Advisory Council of TAPPI was explained. Mr. Macdonald noted that the next meeting of this council would be held immediately before the Executive Committee meeting on Sunday, Feb. 22, 1959. Since the Joint Advisory Council meeting will be attended by division chairmen as well as local section chairmen, it may be advisable to have the local section chairmen meet again later in the week to discuss matters of primary interest to local sections.

Meetings of the Association

In addition to the Annual Meeting the Association held 10 functional conferences during 1958. The details of these meetings have been published in *Tappi* during the year.

1958 Annual Meeting

The 43rd Annual Meeting of the Association was held in New York, N. Y., on Feb. 17–20, 1958. Technical sessions and committee meetings were staged in the Commodore, Biltmore, and Roosevelt Hotels. In spite of heavy blizzards more than 2200 individuals registered and 130 papers were presented. The annual luncheon was featured by an address by L. M. Currie of Union Carbide Corp., New York, N. Y., on "Nuclear Energy As We Start 1958." The TAPPI Medal was presented to Walter H. Swanson, vice-president, Kimberly-Clark Corp., Neenah, Wis. by Roy P. Whitney, The Institute of Paper Chemistry, Appleton, Wis.

Ninth Coating Conference

The Ninth Coating Conference was held at the Bedford Springs Hotel, Bedford, Pa., on May, 14–16, 1958. Over 600 people attended this conference which featured 16 technical papers and panel discussions on "Coating Formulations" and "Practical Rheology." C. G. Landes, American Cyanamid Co., Stamford, Conn., served as conference chairman; E. R. Padavic, Container Corp. of America, Santa Clara, Calif., was program chairman; J. D. Lohnas, West Virginia Pulp & Paper Co., Luke, Md., was local arrangements chairman; and R. W. Hagemeyer, Wyandotte Chemical Corp., Wyandotte, Mich., served as publicity chairman. The official banquet featured an entertaining review of his writing experiences by Pete Martin of *The Saturday Evening Post*, Philadelphia, Pa. Mill visits were made to the Tyrone and Williamsburg plants of West Virginia Pulp and Paper Co., the Spring Grove plant of P. H. Glatfelter Co., the Lock Haven plant of the New York and Pennsylvania Co., and the Kobata plant of Koppers Co.

Seventh Statistics Course

The Seventh TAPPI-CPPA Statistics Course was held at Laval University, Quebec City, Que. on July 7–18, 1958. Thirty-six men attended the conference which included basic course and an advanced seminar. K. E. Vroom, Pulp and Paper Research Institute of Canada; R. G. Belcher, Canadian International Paper Co.; and J. Chollet, Anglo Paper Products Ltd., presented the basic course, while H. A. Freeman, Massachusetts Institute of Technology, and C. E. Noble, Kimberly-Clark Corp., conducted the advanced seminar.

Thirteenth Engineering Conference

The Thirteenth Engineering Conference was held at the Multnomah Hotel, Portland, Ore. on July 28–Aug. 1, 1958. Over 558 delegates and 171 ladies attended this meeting. The conference was sponsored by the Engineering Division of TAPPI with J. R. Curtis, Scott Paper Co., Chester, Pa., serving as general chairman. J. M. Wilcox, Electric Steel Foundry Co., Portland, Ore., was local arrangements committee chairman. The conference included the presentation of 44 technical papers, 12 discussion sessions, an official dinner, an Engineering Division luncheon, and visits to the Clatsop Tree Farm of Crown Zellerbach, the Longview plants of Longview Fibre Co., and the Weyerhaeuser Pulp Division, the Camas and West Linn plants of Crown Zellerbach Corp., and the Oregon City plant of the Publishers' Paper Co. Featured speaker at the official dinner was H. R. J. Grosch, International Business Machines Co., White Plains, N. Y. His subject was "Operations Research." At the Engineering Division luncheon the principal speech was given by W. E. Gove, E. M. C. Recordings, St. Paul, Minn.

Third International Mechanical Pulping Conference

The Third International Pulping Conference, jointly sponsored by TAPPI and the Technical Section, Canadian Pulp and Paper Association, was held on Sept. 10–12, 1958, at the Chateau Frontenac, Quebec, Que. The conference was attended by 280 delegates from 14 countries and featured four panel discussions, 12 technical papers, and visits to the plants of Canadian Glassine Co., Building Products Ltd., J. Ford and Co. Ltd., Bishop Asphalt Papers Ltd., Donnacona Paper Co. Ltd., Anglo-Canadian Pulp and Paper Mills Ltd., Ste. Anne Paper Co. Ltd., and Donohue Bros. Ltd. General conference chairman was J. K. Kirkpatrick, Bowaters Southern Paper Corp., Calhoun, Tenn.; program chairman was E. H. Johnson, Stevens and Thompson Paper Co., Greenwich, N. Y.; and local arrangements chairman was T. G. Shepherd, Donnacona Paper Co., Donnacona, Que. Otto Brauns, Central Laboratories of the Swedish Paper and Mechanical Pulp Industries, Stockholm, Sweden, gave the keynote address on the subject "Through the Years and the Years to Come with Groundwood." Featured speaker at the official banquet was L. R. Thiesmeyer, Pulp and Paper Research Institute of Canada, who spoke on "Science, Scientists, and Social Change."

Third International Fundamental Research Symposium

The Third International Fundamental Research Symposium was held at the Queen Elizabeth Hotel, Montreal, Que., on Sept. 15–17, 1958. Jointly sponsored by the Technical Section, Canadian Pulp and Paper Association, and TAPPI, this symposium dealt with "Properties of Hardwoods and Their Relation to Pulp and Paper Manufacture." More than 220 delegates from nine countries attended the conference, which featured 14 technical papers and two panel discussions. General conference chairman was A. H. Vroom, Consolidated Paper Corp. Ltd. W. H. Rapson, University of Toronto, was program chairman. The keynote address, "The Importance of Hardwoods to the Pulp and Paper Industry," was given by D. W. Ambridge, Abitibi Power and Paper Co.

Twelfth Alkaline Pulping Conference

The Twelfth Alkaline Pulping Conference was held at the Arlington Hotel, Hot Springs, Ark., on Sept. 24–26, 1958. Over 325 delegates attended this conference, which included three technical sessions on alkaline pulping and one on semichemical pulping. General conference chairman was J. McK. Limerick, Bathurst Power and Paper Co., Montreal, Que. Program chairman of the Alkaline Pulping Sessions was D. O. Adams, West Virginia Pulp and Paper Co., Covington, Va. R. E. Collins, The Crossett Co., Crossett, Ark., served as program chairman for the Semichemical Pulping Session. Local arrangements committee chairman was W. B. Stengle, The Crossett Co., Crossett, Ark. The conference featured 16 technical papers and visits to the Pine Bluffs plant of Dierks Paper Co., and the Camden plant of International Paper Co. Featured speaker at the Wednesday Luncheon was Leo Aikman, "The Atlanta Constitution," Atlanta, Ga., who spoke on "The 'You' in Automation."

Ninth Testing Conference

The Ninth TAPPI Testing Conference was held at the General Oglethorpe Hotel, Savannah, Ga., Sept. 30–Oct. 3, 1958. More than 290 delegates attended the meeting, which featured four technical sessions, 15 papers, an instrument exhibit, and meetings of the Testing Division Committees. "Paperboard Testing" was the conference theme. The TAPPI Graphic Arts Committee sponsored one of the four technical sessions. General conference chairman was R. B. Hobbs, National Bureau of Standards, Washington, D. C.; W. H. Aiken, Diamond-Gardner Corp., Middletown, Ohio, was program chairman; and H. T. Robson, Union Bag-Camp Paper Corp., Savannah, Ga., was local arrangements chairman. P. W. Bartholomew, Minnesota and Ontario Paper Co., International Falls, Minn., retired as Testing Division Chairman and was succeeded by C. E. Brandon, Miami University, Oxford, Ohio. Featured speaker at the banquet was M. M. Batzer, consultant, Philadelphia, Pa., who spoke on the subject "Does It Pay to Worry About Fire?" Plant tours were made to Union Bag-Camp Paper Co. and Southern Paperboard Co. plants in Savannah and to the Herty Foundation.

Third Deinking Conference

The Third Deinking Conference was held at the Dayton Biltmore Hotel, Dayton, Ohio, on Oct. 8–10, 1958. One hundred twenty-seven people attended this meeting, which featured two technical sessions and three plant visits. This conference was sponsored by the TAPPI Deinking Committee under the chairmanship of J. J. Forsythe, International Paper Co., Niagara Falls, N. Y. Conference chairman was A. J. Felton, The Black-Clawson Co., Middletown, Ohio, and program chairman was W. D. Rice, P. H. Glatfelter Co., Spring Grove Pa. The conference banquet was jointly sponsored by the Deinking Committee and the Ohio Section of TAPPI and featured a speech by D. W. Curtis, Beloit Iron Works, Beloit, Wis., on "Education for Pulp and Paper Careers." Visits were made at the Standard Register Co., and the McCall Corp., plants in Dayton and the Black-Clawson plants in Middletown and Hamilton.

Thirteenth Plastics-Paper Conference

The Thirteenth Plastics-Paper Conference was held at the Sheraton-Kimball Hotel in Springfield, Mass., on Oct. 20–22, 1958. A record attendance of over 350 people attended this conference which featured three technical sessions, meetings of the Plastics and Plastic Laminates Committees, and visits to Monsanto Chemical Co., Shawinigan Resins, Inc., Strathmore Paper Co., and U. S. Rubber Co. Chairman of the Converting and Consuming Division, which sponsored this conference was R. C. Sturken, Frank W. Egan and Co., Somerville, N. J. Conference chairman was R. W. Reiter,

National Starch Products, Inc., Plainfield, N. J.; R. G. Hochschild, Koppers Co., Inc., Monaca, Pa., was program chairman; and W. N. Stickel, Texon, Inc., South Hadley Falls, Mass., handled local arrangements. The conference banquet was highlighted by an address by President Arthur Bronwell of Worcester Polytechnic Institute on the subject "Can We Maintain a Philosophy of Progress?"

Eighth Corrugated Containers Conference

The Eighth Corrugated Containers Conference was held at the Netherland Hilton Hotel, Cincinnati, Ohio, on Nov. 4-6, 1958. Over 440 delegates attended this two-day meeting which featured technical sessions on "Indirect Labor" and "New Developments in the Corrugated Box Industry." The conference was sponsored by the TAPPI Corrugated Containers Division under the chairmanship of R. L. Jenk, The Mead Corp., Chillicothe, Ohio. E. O. Knapp, Hinde and Dauch Div., West Virginia Pulp and Paper Co., Sandusky, Ohio, served as conference chairman. Featured speaker at the conference banquet was G. W. Heumann, General Electric Co., who presented a talk on "Impressions of Russia." During the second day visits were made to the River Raisin Paper Co., Sharonville, Ohio, and the Proctor and Gamble Co., Cincinnati, Ohio.

Research Projects

During 1958 the Association made research grants amounting to $66,584. A detailed report of these research projects is included in the report of the chairman of the Research Appropriations Committee.

Divisions and Committees

During 1958 the following changes were made in the division and committee structures.

In the Converting and Consuming Division a Plastic Laminates Committee was established.

In the Engineering Division a Staff Advisory Committee and a Civil Engineering Committee were established, and the Hydraulics Committee became a subcommittee of the Fluid Mechanics Committee. The Industrial Engineering Committee was renamed the Industrial Engineering and Materials Handling Committee.

In the Research and Development Division a Wood Chemistry Committee was established.

In the Testing Division five groups of committees were established. The Technical Services Group includes the Chemical Methods Committee, the Microscopy Committee, the Optical Properties Committee, the Physical Methods Committee, a Precision Committee, and the Routine Control Methods Committee. The Nonfibrous Raw Materials Group contains the Adhesives Testing Committee, the Fillers and Pigments Testing Committee, the Pulping, Bleaching, and Papermaking Chemicals Testing Committee, and the Wax Testing Committee. In the Pulping Group are the Fibrous Raw Materials Testing Committee and the Pulp Testing Committee. The Paper and Paperboard Group includes the Paper Testing Committee, the Packaging Materials Testing Committee, the Paperboard Testing Committee, and the Paper Shipping Sack Testing Committee. The Converted Products and Structural Materials Group includes the Container Testing Committee.

Many changes in committee and division officers were made. These were as follows:

Coating and Graphic Arts Division: R. T. Trelfa, Perkins-Goodwin Co., Kalamazoo, Mich., became division secretary. In the Coating Committee A. D. Bonanno, Kelco Co., New York, N. Y., succeeded J. D. Davis, The Mead Paper Corp., Chillicothe, Ohio as committee chairman, J. T. Loomer, Continental Can Co., New York, N. Y. succeeded A. D. Bonanno as committee vice-chairman, and J. E. Wilber, St. Regis Paper Co., Deferiet, N. Y. succeeded J. T. Loomer as committee secretary.

Converting and Consuming Division: R. C. Sturken, The Frank W. Egan Co., Somerville, N. J. succeeded the late R. T. Nazzaro, Westfield River Paper Co., as division chairman. W. N. Stickel, Texon Inc., South Hadley Falls, Mass., succeeded W. A. Schenck, Riegel Paper Corp., Riegelsville, N. J. as chairman of the Plastics Committee. H. A. Spencer, Knowlton Bros., Watertown, N. Y., succeeded P. M. Goodloe, Brown Co., Berlin, N. H., as chairman of the Plastic Laminates Committee. C. J. Seiler, General Electric Co., Coshocton, Ohio was named vice-chairman of the Plastic Laminates Committee, and W. E. Morris, was appointed secretary of the committee.

Corrugated Containers Division: R. L. Jenk, The Mead Corp., Chillicothe, Ohio succeeded L. K. Burnett, The Ohio Boxboard Co., Rittman, Ohio as division chairman, and B. Mendlin, Cornell Paperboard Products, Milwaukee, Wis., succeeded R. L. Jenk as division vice-chairman. In the Corrugated Containers Engineering Committee R. C. Hutcheson, Union Bag-Camp Paper Corp., Savannah, Ga., was named vice-chairman. W. C. Kline, Container Corp. of America, Chicago, Ill., was named chairman of the Corrugated Containers Industrial Engineering Committee. M. Block, Stone Container Corp., Chicago, Ill., replaced R. L. Jenk, The Mead Corp., Chillicothe, Ohio as chairman of the Corrugated Containers Raw Materials Committee, D. C. Shepard, Jr., Menasha Wooden Ware Co., Menasha, Wis., was named vice-chairman, and R. Wilmer, was named committee secretary.

Engineering Division: V. P. Owens, Combustion Engineering Co., New York, N. Y., was named division secretary. E. H. Olmstead, The Eaton Dikeman Co., Mt. Holly Springs, Pa., and W. C. Bloomquist, General Electric Co., Philadelphia, Pa. were named chairman and secretary, respectively, of the Staff Advisory Committee. W. C. Pittam, Stone and Webster Co., Boston, Mass., was named chairman of the Civil Engineering Committee. E. W. Hopper, Pittsburgh, Pa., succeeded L. DelaGrange, West Virginia Pulp and Paper Co., New York, N. Y., as chairman of the Corrosion Committee. H. W. Fritts, Aluminum Company of America, New Kensington, Pa., succeeded G. M. Stevens, Babcock and Wilcox Co., New York, N. Y., as Corrosion Committee secretary. On the Engineering Data Committee H. G. Ingraham, Charles T. Main, Inc., Boston, Mass., succeeded F. D. Heleversen, Crown Zellerbach Corp., San Francisco, Calif., as committee chairman. On the Electrical Engineering Committee, I. Witham, Byron Weston Co., Dalton, Mass., was named committee vice-chairman. On the Industrial Engineering and Materials Handling Committee B. C. Kendall, Crown Zellerbach Corp., San Francisco, Calif., succeeded J. M. MacBrayne, Union Bag-Camp Paper Co., Savannah Ga., as committee chairman. D. D. Hall, The E. B. Eddy Co., Hull, P. Q., Canada, succeeded B. C. Kendall as committee vice-chairman. J. S. Mudgett, Strathmore Paper Co., West Springfield, Mass., was named vice-chairman of the Mechanical Engineering Committee. In the Process Instrumentation and Control Committee E. W. Prince, Champion Paper and Fibre Co., Hamilton, Ohio succeeded R. G. Spangler, P. H. Glatfelter Co., Spring Grove, Pa., as committee vice-chairman. W. A. Moggio, Lake States Yeast Corp., Rhinelander, Wis., succeeded G. M. Griffith, West Virginia Pulp & Paper Co., Luke, Md., as chairman of the Sanitary Engineering Committee. W. B. Wilson, General Electric Co., Schenectady, N. Y., succeeded V. P. Owens, Combustion Engineering Co., New York, N. Y., as secretary of the Steam and Power Committee.

Industrial Division: R. M. Wilkinson, Alton Boxboard Co., Alton, Ill., succeeded F. D. Grunwald, Consolidated Paper Co., Monroe, Mich., as vice-chairman of the Agricultural Fibers Committee. On the Structural Fibrous Materials

Committee R. S. von Hazmburg, U. S. Gypsum Co., Chicago, Ill., succeeded J. J. Perot, The Flintkote Co., Whippany, N. J., as committee chairman. W. H. McPherson, Minnesota and Ontario Paper Co., International Falls, Minn., succeeded R. S. von Hazmburg as committee secretary. On the Water Committee J. S. G. Shotwell, New York, N. Y., succeeded A. Thurn, Champion Paper and Fibre Co., Hamilton, Ohio as committee chairman, and J. G. Patrick, West Virginia Pulp and Paper Co., Luke, Md., succeeded J. S. G. Shotwell as vice-chairman.

Pulp Manufacture Division: On the Alkaline Pulping Committee H. Y. Charbonnier, Union Bag-Camp Paper Co., Savannah, Ga., was replaced by J. M. Limerick, Bathurst Power and Paper Co., Montreal, P. Q., Canada as committee chairman. K. D. Running, Halifax Paper Co., Roanoke Rapids, N. C., succeeded J. M. Limerick as committee vice-chairman. P. B. Borlew, National Container Co., Jacksonville, Fla., succeeded A. Pollak, New York, N. Y. as chairman of the Chemical Products Committee. On the Dissolving Pulps Committee R. H. MacClaren, Eastman Kodak Co., Rochester, N. Y., succeeded G. K. Greminger, Jr., Dow Chemical Co., Midland, Mich., as committee secretary. A. A. Yankowski, Kimberly Clark Corp., Neenah, Wis., replaced J. H. White, Keyes Fibre Co., Waterville, Me., as chairman of the Mechanical Pulping Committee. On the Deinking Committee J. J. Forsythe, Jr., International Paper Co., Niagara Falls, N. Y. succeeded A. M. Altieri, Tileston and Hollingsworth Co., Hyde Park, Mass., as committee chairman, and W. D. Boggess, Beveridge Paper Co., Indianapolis, Ind., was named committee vice-chairman. E. F. Andrews, International Paper Co., Niagara Falls, N. Y., replaced J. W. Morrow, Newton Falls Paper Mills, Newton Falls, N. Y. as committee secretary. F. Kraft, Marathon Paper Div., American Can Co., Menasha, Wis., was named Pulp Purification Committee chairman replacing F. P. Doane, Jr., Bergstrom Paper Co., Neenah, Wis. F. Casciani, P. H. Glatfelter Co., Spring Grove, Pa., was named committee vice-chairman, and D. J. MacLaurin, Institute of Paper Chemistry, Appleton, Wis., was named committee secretary. On the Semichemical Pulping Committee P. E. Trout, Waldorf Paper Products Co., Saint Paul, Minn., was named committee vice-chairman replacing W. W. Marteny, Continental Can Co., Greenville, S. C. S. R. Parsons, Consolidated Water Power and Paper Co., Wisconsin Rapids, Wis., succeeded P. E. Trout as committee secretary.

Research and Development Division: On the Fundamental Research Committee R. P. Whitney, Institute of Paper Chemistry, Appleton, Wis., succeeded H. F. Lewis, Institute of Paper Chemistry, Appleton, Wis., as committee chairman. On the Microbiological Committee R. S. Williams, Vanderbilt Co., Norwalk, Conn., was succeeded by W. M. van Horn, Institute of Paper Chemistry, Appleton, Wis., as committee chairman. G. R. Hunt, Jr., Nalco Co., Chicago, Ill., was named vice-chairman, and A. N. Stern, West Virginia Pulp and Paper Co., Covington, Va., was appointed secretary of the Microbiological Committee. R. Salvesen, Marathon Paper Div., American Can Co., Rothschild, Wis., was named chairman of the Wood Chemistry Committee.

Testing Division: C. E. Brandon, Miami University, Oxford, Ohio, was named division chairman replacing P. W. Bartholomew, Minnesota and Ontario Paper Co., International Falls, Minn. D. N. Obenshain, West Virginia Pulp & Paper Co., Luke, Md., was named chairman of the Technical Services Group. K. H. Williams, Mid-States Gummed paper Co., Argo, Ill., was selected as chairman of the Nonfibrous Raw Materials Group. H. A. Smith, Mead Co., Chillicothe, Ohio was named chairman of the Pulping Group. A. R. Ewing, Bemis Bros Bag Co., Boston, Mass., was selected as chairman of the Paper and Paperboard Group. T. E. Dobbins, American Can Co., Maywood, Ill., was selected as chairman of the Converted Products and Structural Materials Group. On the Chemical Methods Committee E. F. Thode, Institute of Paper Chemistry, Appleton, Wis., was succeeded by W. K. Wilson, National Bureau of Standards, Washington, D. C. as committee secretary. On the Physical Methods Committee R. E. Green, Thwing-Albert Instrument Co., Philadelphia, Pa., was named committee chairman, C. F. Ackerman, Union Mills Paper Manufacturing Co., New Hope, Pa., was appointed vice-chairman, and R. P. Anderson, St. Regis Paper Co., Pensacola, Fla., was named committee secretary. T. W. Lashof, National Bureau of Standards, Washington, D. C., was named vice-chairman of the Precision Committee, and G. L. Maton, John I. Thompson and Co., Washington, D. C., was selected as committee secretary. On the Routine Control Methods Committee F. A. Delforge, Continental Can Co., Uncasville, Conn., was succeeded as chairman by J. R. Gunning, Provincial Paper Ltd., Georgetown, Ont., Canada. B. Q. Haynes, B. F. Perkins & Sons, Inc., Holyoke, Mass., was named committee secretary. W. Neuss, Stein Hall and Co., Long Island City, N. Y., W. W. Sederlund, National Starch Products Co., Plainfield, N. J., and J. P. Karey, Jr., Denninson Manufacturing Co., Framingham, Mass. were named chairman, vice-chairman, and secretary, respectively, of the Adhesives Testing Committee. On the Fillers and Pigments Testing Committee W. R. Willets, Titanium Pigment Corp., New York, N. Y. was named committee chairman, W. H. Kreiling, Lowe Paper Co., Ridgefield, N. J. was selected as vice-chairman, and S. J. Batruk, The New Jersey Zinc Co., New York, N. Y. was named secretary. T. S. Morse, Hercules Powder Co., Wilmington, Del. was named chairman of the Pulping, Bleaching, and Papermaking Chemicals Testing Committee. On the Wax Testing Committee M. W. Kane, The KVP Co., Parchment, Mich. succeeded G. G. Rumberger, Marathon Div., American Can Co., Menasha, Wis., as committee chairman. E. L. Walker, Standard Oil Co. (Indiana), Chicago, Ill., succeeded W. J. Yates, Shell Oil Co., New York, N. Y. as committee secretary. K. A. Arnold, St. Regis Paper Co., New York, N. Y., succeeded A. R. Ewing, Bemis Bros. Bag Co., Boston, Mass., as committee chairman.

Research Appropriations Committee

During 1958 twenty-two appropriation requests were received from Association committees for the purpose of financing their projects. These requests totaled $117,084.22. The Executive Committee made available $60,000 at its February, 1958, meeting, and an additional appropriation ($80,000), $66,584.22 has been apportioned by the Research Appropriations Committee in the form of 13 grants.

The 22 requests were received from 16 different committees, which fact indicates the increasing interest in the financing of their activities by means of Association funds. Thirteen requests were new ones, and nine were renewals. Of the grants made, eight were renewals and five were new. Unfortunately, the amount available from the Association was considerably less than the demands of the various committees. This situation made it necessary for the Research Appropriations Committee to appraise all requests very carefully.

The procedure adopted in 1957 of considering appropriation requests twice a year (April 1 and October 1) was followed in 1958. This arrangement seemed to be a satisfactory one. Rejection of a request occurs when more than two negative votes are cast by the committee.

To aid the Research Appropriations Committee in reaching its decision on grants, committee chairmen are urged to furnish the information on their requests in accordance with the form suggested in item 3, under "Regulations Governing Research Appropriations," on page 44 in the 1958–1959 TAPPI Year Book. All committee and division officers have received the "Memorandum on TAPPI Research Proposals" from P. E. Nethercut. This should be consulted before an appropriation request is submitted in order to save time and

Technical Association of the Pulp and Paper Industry Appropriations Requests Received and Grants Made in 1958

Request number	New or renewal	Project	Committee	Amount Requested	Amount Granted
142	N	Development of a Micro Pulping Procedure for Small Wood Samples	Chemical Methods	$ 5,000	$ ....
143	N	Relationship and Sensitivity of Air-Leak Smoothness Testers	Paper Testing	2,800	2,800
144	R	Study of Flow Properties of Paper Coating Mixtures	Coating	3,681.09	3,681.09
145	N	Transfer Aspects of Ink Receptivity	Graphic Arts	12,000	....
146	R	Preparation and Chemical Properties of the Polymer-homologous Oligosaccharides of the Cellulose Series	Wood Chemistry	2,825	2,825
147	R	Characteristics of Flow with Dilute Fiber Suspensions	Fluid Mechanics	16,500	16,500
148	N	The Investigation of the Variables of Stock Preparation of Semichemical Hardwood Pulps	Semichemical Pulping	4,500	....
149	R	Permeability of Plastic Treated Paper to Gases and Liquids	Plastics	2,400	2,400
150	N	Condensate Removal from Paper Driers	Drying	3,500	....
151	N	Properties of Plastic Materials (Sticky Types) Objectionable in Deinked Pulp, Either Due to Appearance or Due to Properties Such as Tackiness	Deinking	8,000	....
152	N	Development of a Method for the Determination of Xylan in Purified Pulps Based on the Isotope-Dilution Technique	Chemical Methods	5,000	....
153	N	Mechanism of Bleaching of Lignin in Aqueous Chlorine, Chlorine Dioxide, and Chlorite Systems	Wood Chemistry	3,900	3,900
154	N	Preparation of a Critical, Up-to-date Report Analyzing Information Available on Pulp and Paper Brightness Recession	Pulp Purification	3,000	3,000
155	R	Study of Flow Properties of Coating Mixes	Coating	1,435	1,453
156	R	Instability of Stock on the Fourdrinier Wire	Fluid Mechanics	14,000	14,000
157	R	Construction of Two Vapor Transmission Testers	Structural Fibrous Materials	2,000	....
158	N	Study of the Variables in Water Absorption Testing of Structural Insulating Board	Structural Fibrous Materials	1,500	
159	N	Properties of Paper Affecting Adhesion of Extruding Resins	Plastics	9,000	....
160	R	The Reactions of Aqueous Chlorine with Simple Carbohydrates	Fundamental Research	3,443.13	3,434.13
161	R	Mechanism of Retention of Wet Strength Resins	Wet Strength & Interfiber Bonding	10,000	10,000
162	N	Effect of Closed White Water Systems on Groundwood Brightness by Determination of Factors Causing Discoloration	Mechanical Pulping	600	600
163	N	Sampling Plans for the Acceptance or Rejection of Skid Lots of Paper	Statistics	2,000	2,000
Total				$117,084.22	$66,584.22

Requests 142–150 were given consideration in April, 1958; requests 151–163, in October, 1958.
Twenty-two requests were received in 1958; 13 grants were made, and 9 requests were denied.

unnecessary correspondence. A properly prepared request greatly facilitates the work of the Research Appropriations Committee.

Close liaison between division and committee chairmen is very desirable in connection with committee activities, especially where Association financing is concerned. It is a requirement that divisional chairmen must endorse all appropriation requests, and must also approve all reports on TAPPI-financed projects in advance of publication.

A statement of the TAPPI research policy was published in the March, 1958, issue of *Tappi* on page 111 A. This policy was adopted by the Executive Committee, September, 1957.

The Research Appropriations Committee wishes to acknowledge the valuable assistance of P. E. Nethercut of the headquarters staff. He prepared the "Semiannual Progress Report" and submitted a memorandum on the "Availability of Government and Private Foundation Funds for TAPPI Research Programs," which formed a part of the "1958 Semiannual Report."

With the conclusion of the 1959 Annual TAPPI Meeting three members retire in accordance with the policy of a rotating membership and a 3-year tenure. The retiring members are G. J. Brabender, V. P. Edwardes, and J. H. Heuer. As their successors, the Executive Committee has appointed Abbott Byfield, Glen Renegar, and J. J. Thomas.

For 1959, the personnel of the Research Appropriations Committee comprises the following members:

J. R. Lientz (ex-officio)
H. M. Annis (ex-officio)
K. O. Elderkin (1959)
R. H. Doughty (1960)
J. D. Lyall (1960)
A. Byfield (1961)
M. S. Kantrowitz (1959)
H. S. Gardner (1959)
W. C. Bloomquist (1960)
G. Renegar (1961)
J. J. Thomas (1961)
J. L. Parsons, Chairman

John L. Parsons, *Chairman*
Research Appropriations Committee

PROGRESS REPORTS ON COMMITTEE PROJECTS CURRENTLY FINANCED BY TAPPI RESEARCH GRANTS

Coating and Graphic Arts Division (H. O. Ware, General Chairman)

Coating Committee (A. D. Bonanno, Chairman) Grants No. 111 ($6805) in 1957, No. 144 ($3681.09) and No. 155 ($1435) in 1958. Flow Properties of Paper Coating Mixes. An attempt has been made to analyze the rheograms obtained from coating colors from selectively fractionated clay samples, but because of the limited size of these samples no conclusive data were obtained from the rheograms. This work is being continued with additional samples of fractionated clay. A statistical analysis of the results has been made using an IBM 704 computer at M. I. T. A paper on this phase of the work will be presented at the May, 1959, Coating Conference in Boston.

A continuing study of particle size and particle size distribution is now under way and should be nearly completed by June, 1959. These results will also be subjected to a statistical analysis. Data have been accumulated on particle size distribution from x-ray studies.

This investigation is being carried out at the University of Maine. Besides a Hercules roll coater, the University has received through donations a Dilts Contracoater and an S. D. Warren laboratory knife coater. Up to the present time three Master's degrees candidates have worked on TAPPI coating projects: one has completed the degree, one has transferred to The Institute of Paper Chemistry, and the other expects to complete his degree by August, 1959. In addition, several students have gained valuable experience in the paper coating field by working on this TAPPI project and plan to enter this industrial field. Financial statement:

Personnel charges	$2173.81
Service charges (25%)	543.45
Supplies	123.05
Phone & telegraph	14.20
Travel	181.34
Grad. student tuition	132.50
Total	$3168.35
Balance (Dec. 31, 1958)	512.74

No funds have been drawn from Grant No. 155 to this date.

Graphic Arts Committee (C. A. Morton, Chairman) Grant No. 130 ($10,000) in 1957. Surface Strength of Paper. During 1958 an intensive research program has been started at Lehigh University toward the goal of establishing a reliable TAPPI standard for prediction of the surface strength of paper. Manufacturers of pick instruments have cooperated in supplying equipment free of charge for the study. Also several special instruments were made available to the group. A total of 26 paper and paperboard companies have provided samples or round-robin test results. Up to this date a satisfactory standard instrument or method has not been produced. A complete analysis of each of the available instruments, and methods being used has been made, and two comprehensive reports have been issued by Lehigh University covering:

1. Evaluation of all commercially available instruments with respect to reproducibility and ability to differentiate between papers.

2. Round-robin tests made by a number of cooperating mills and other laboratories. Lehigh's digital computer was used for statistical analysis of the data.

In the opinion of the subcommittee, the work to date has been pursued with vigor and with the original goal well in mind. Plans are to be discussed by the committee towards the condensing of the above two reports into one report for wider distribution. Financial report:

Salaries	$8,760
Overhead	4,380
Misc.	920
Total	$14,060

The difference between the TAPPI Grant ($10,000) and the actual expense was appropriated by the Printability Research Fund of Lehigh University.

Converting and Consuming Division (R. C. Sturken, General Chairman)

Plastics Committee (W. N. Stickel, Chairman) Grants No. 89 ($7400) in 1956, No. 120 ($2200) in 1957, and No. 149 ($2400) in 1958. Permeability of Plastic Films and Treated Papers to Gases and Liquids. The project is now in its terminal year and the final report will deal in detail with the problem of water vapor transmission through plastic films. To date five reports have been submitted by the State University of New York College of Forestry to the committee. It is probable that a paper on this subject will be presented at the 1959 TAPPI Paper-Plastics Conference. Financial statement:

Total of three TAPPI Grants (1956–58) is $12,000.

Personal services	$8,647.42
OASI	10.74
Travel	118.16
Supplies	1,381.14
Overhead	500.00
Total	$10,657.46
Balance (Dec. 31, 1951)	1,342.54

Wet Strength and Interfiber Bonding Committee (K. W. Britt, Chairman) Grant No. 117 ($5000) in 1957. Study of the Mechanism by Which Wet Strength Resins Are Taken Up by Papermaking Fibers. This project was terminated Jan. 31, 1958. Two papers describing the results of the research are awaiting publication. The work was done at The Institute of Paper Chemistry.

Grant No. 118 ($5250) in 1957. Study of the Fundamentals of Cure in the Development of the Wet Strength of Paper. This project, being investigated at the State University of New York College of Forestry, will be completed by the end of February 1959, at which time the grant will be exhausted. A paper, "Studies on the Mechanism of Wet Strength Development," I, by T. Lindh, S. E. Church, and V. Stannett, was published in *Tappi* 41: 465–468 (September, 1958).

Grant No. 161 ($10,000) in 1958. Mechanism of Retention of Wet Strength Resins. This project has not been started as yet. Details of the work to be carried out at The Institute of Paper Chemistry will be discussed during the 1959 Annual TAPPI Meeting.

Engineering Division (J. R. Curtis, General Chairman)

Chemical Engineering Committee (A. W. Plummer, Chairman) Grant No. 121 ($1400) in 1957. A Study of the Humidity Measurement in Gas Streams Containing Water-Soluble Gases at Temperatures up to 200°C. This project was closed in August, 1957, and the grant was expended. This study was made at the University of Wisconsin and was partially financed by funds from the Wisconsin Alumni Research Foundation.

Fluid Mechanics Committee (N. Shoumatoff, Chairman) Grants No. 126 ($15,500) in 1957 and No. 147 ($16,500) in 1958. Characteristics of Flow in Dilute Fiber Suspensions. Committee project No. 715. The phase of the project financed by Grant No. 126 was terminated on Oct. 31, 1958, with a final expenditure of $16,585.89. The major results of the study were presented verbally by Dr. J. W. Daily at the TAPPI Engineering Conference in Portland, Ore. on July 28, 1958. The final manuscript of this report incorporating results through October 31 is due to be submitted to the committee on Feb. 1, 1959, for publication in *Tappi* after necessary review and approval. A subcommittee meeting on this project was held at the MIT, Cambridge, Mass., on May 5, 1958, and the minutes published in *Tappi*, July, 1958. This project has yielded a tremendous amount of data which have been extensively analyzed. It makes available for the first time quantitative information about intensity and scale of turbulence with flowing fibers which was the main object of the study, along with correlated information on deviations from behavior of ordinary fluids. To aid in financing this project the Clark and Vicario Corp. made a contribution of $1000. Work under Grant No. 147 began on Nov. 1, 1958. This is a direct continuation of Project No. 126. The first review of results will be held at a subcommittee meeting at Cambridge, Mass., in March or April, 1959. Project results are to be presented at the Engineering Conference in Pittsburgh, Pa., October, 1959. The work is being done at the Massachusetts Institute of Technology.

Grants No. 140 ($12,000) in 1957 and No. 156 ($14,000) in 1958. Instability of Stock on the Fourdrinier Wire. The phase of the project financed by Grant No. 140 was terminated Dec. 31, 1958, with a total expenditure of $11,565.34.

A progress report was presented at the Engineering Con-

ference in Portland, Ore., on July 29, 1958. The final report is to be presented in New York on Feb. 24, 1959, and will be submitted for publication in *Tappi*. Progress was reviewed at two subcommittee meetings held in Ann Arbor, Mich. on Jan. 7, 1958 (published in *Tappi*, April, 1958) and Jan. 16, 1959. This project has resulted in new mathematical theories on the growth of disturbances at a paper machine table roll which have been verified experimentally with a special hydraulic model constructed for this purpose. The work has established that (a) only a narrow range of frequencies of disturbance is amplified at the table roll itself, (b) growth of disturbance in the region after the table roll has been measured, but the mathematical theory is still incomplete, and (c) formation of circular ridges around the table roll and other instances of curved free-surface flow have been fully correlated with flow conditions both theoretically and experimentally.

Grant No. 156 applies to the period beginning Jan. 1, 1959. Plans for the work were reviewed at the subcommittee meeting at Ann Arbor, Mich. on Jan. 16, 1959. A progress report will be presented at the Engineering Conference at Pittsburgh, Pa., in October, 1959. The work is being done at the University of Michigan.

Industrial Division (W. H. Aiken, General Chairman)

Structural Fibrous Materials Committee (R. S. von Hazmburg, Chairman) Grants No. 29 ($1000) in 1951 and No. 41 ($512.60) in 1952. Testing of Two Drainage Testers. This project during 1958 has been brought nearly to completion. The two drainage time testers, which were constructed, have been for several years circulating to various interested mills and laboratories. From each location a complete questionnaire was taken after a complete test. There remain three locations to be completed, and it is anticipated this can be accomplished during 1959. The project would then be ready for a final summarization. The committee feels that the work has been unusually successful and that the insulating board industry and others interested in the testing of extremely free fibers owe a debt to TAPPI for this undertaking. Thus far the questionnaires have an unusually high percentage favorable to the instrument.

Grant No. 33 ($2500) in 1951. Description of a Method of Test for the Racking Strength of Insulation Board Sheathing. A test program on the relationship of lateral nail resistance and ultimate load in racking strength was carried out at the U. S. Forest Products Laboratory. A report on these tests was presented at the 1958 meeting of the committee. This was later published under the title, "Racking Strength and Lateral Nail Resistance of Fiberboard Sheathing," by R. H. Neisel, in *Tappi* 41: 735–737 (December, 1958). $2,400 of the Grant has been spent.

Grant No. 108 ($1000) in 1956. Testing of a Test Board Machine for Structural Fibrous Materials. The test board machine is presently being evaluated by various companies

Pulp Manufacture Division (M. B. Pineo, General Chairman)

Acid Pulping Committee (P. J. Frost, Chairman) Grant No. 66 ($5000) in 1954. Thermodynamic Properties of the Systems: Sulphur Dioxide–Water–Ammonia, Sulphur Dioxide–Water–Sodium Oxide, Sulphur Dioxide–Water–Calcium Oxide, and Sulphur Dioxide–Water–Magnesium Oxide. The research conducted at the University of Washington during 1958 is being reported at the TAPPI 1959 Annual Meeting, under the title "Correlation of Vapor-Liquid Equilibria in the Systems Sulphur Dioxide–Water–Ammonia and Sulphur Dioxide–Water–Sodium Oxide Using an IBM 650 Computing Machine." A manuscript describing these and prior results will be submitted for publication in *Tappi*. As circumstances permit, work is being continued by graduate students directed toward securing a useful correlation in the systems sulphur dioxide–water–magnesium oxide and sulphur dioxide–water–calcium oxide. The TAPPI grant is substantially exhausted.

Grant No. 88 ($6000) in 1955. Distribution in Molecular Weights of Lignin. About 70 delignification experiments on hemlock and alderwoods have now been completed under acidic, neutral, and alkaline conditions with sodium hydroxide-sulphurous acid solutions under different temperatures and cooking times. It is contemplated that this work will be published in *Tappi*, and the paper will include a rather complete review of the results of the lignin molecular weight studies carried out at the University of Washington. The funds granted by TAPPI are substantially exhausted.

Mechanical Pulping Committee (A. A. Yankowski, Chairman) Grant No. 162 ($600) in 1958. Effect of Closed White Water Systems on Groundwood Brightness by the Determination of the Factors Causing Discoloration. This project is just being started at the State University of New York College of Forestry. A progress report will be submitted to the committee at the TAPPI Annual Meeting. No money has been expended to date (Jan. 26, 1959).

Pulp Purification Committee (F. Kraft, Chairman) Grant No. 154 ($3000) in 1958. Preparation of a Critical, Up-to-date Report Analyzing Information Available on Pulp and Paper Brightness Recession. The work on this project, at the University of Toronto, will be started May 1, 1959.

Research and Development Division (H. F. Lewis, General Chairman)

Fundamental Research Committee (R. P. Whitney, Chairman) Grant No. 54 ($1500) in 1953. Structure of Lignin. This project is closed. An unexpended balance of $1039.91 was returned by Bucknell University to TAPPI. A report on an earlier phase of the work was published in *Tappi* 36: 342–345 (August, 1953).

Grant No. 116 ($4500) in 1957. Isolation of Dimers from Lignin. This project has been completed. A paper summarizing the earlier work appeared in *Tappi* 41: 64-70 (February, 1958). The work was done at the State University of New York College of Forestry.

Grants No. 97 ($5850) in 1956 and No. 160 ($3443.13) in 1958. Reactions of Aqueous Chlorine with Simple Carbohydrates. The broad objective of this study lies in the field of fundamental chemistry and is concerned with the development of a better understanding of the mechanism of chemical reaction by aqueous chlorine over a wide range of pH. Such studies should provide background knowledge of value in understanding and controlling the processes occurring during the bleaching of cellulosic materials with aqueous chlorine and chlorine compounds. The work is being carried out at Boston University by Manual Urquiza, who is designated as a TAPPI Fellow. The work should be completed by Aug. 31, 1959. Work was suspended on Sept. 1, 1957, and resumed on July 7, 1958, due to a leave-of-absence of the principal investigator. Sufficient funds from Grant No. 97 were available to continue the work to date. Grant No. 160 has not been paid as of Jan. 15, 1959.

Grant No. 115 ($3800) in 1957. Study of the Sulphur Chemistry as Related to the Kraft Process. This investigation, carried out at Vanderbilt University, has been terminated. Two reports on "The Organic Chemistry of Sulphur in the Kraft Process" have appeared in *Tappi* 41: 721–733 (December, 1958).

Grant No. 124 ($4887.82) in 1957. Behavior of Nucleophilic Reagents with Lignin and Lignin Models. A final report will be presented at the 1959 TAPPI Annual Meeting. A paper covering the entire project, carried out at Reed College, is being prepared.

Wood Chemistry Committee (J. R. Salvesen, Chairman) Grants No. 123 ($2225) in 1957, and No. 146 ($2825) in 1958. Preparation and Properties of Polymerhomologous Oligosaccharides of the Cellulose Series. Three papers have been published on the results of this project. The latest publication was in *Tappi* 41: 204 (May, 1958), by M. L.

Wolfrom and D. L. Fields. Compounds lost in the recent fire at the Ohio State University have been prepared again. Preliminary work for the investigation of the sensitivities of the cellodextrins toward alkaline oxidation has been started. An oral report will be presented on the progress of the study at the committee meeting during 1959 TAPPI Annual Meeting week. The funds from Grant No. 146 have been paid.

Grant No. 153 ($3900) in 1958. Mechanism of Bleaching of Lignin in Aqueous Chlorine, Chlorine Dioxide, and Chlorite Systems. This study will be started Feb. 9, 1959. No payment has been made on this Grant. The work be will carried out at the State University of New York College of Forestry.

Microbiological Committee (W. M. Van Horn, Chairman) Grant No. 119 ($5000) in 1957. Development of a Manometric Technique for Determining the B.O.D. of Pulp and Paper Mill Wastes. The results of this investigation, carried out at The Institute of Paper Chemistry, were published in *Tappi* 41: 321–333 (July, 1958). There is now in preparation a tentative proposed TAPPI method which, it is hoped, will eventually become a Standard. The tentative method will be introduced to the committee at its February, 1959, meeting. Research Grants Nos. 90 and 119, totaling $10,000, have been exhausted, and the Institute has more than matched this amount from institutional funds to complete the work.

Statistics Committee (M. S. Renner, Chairman) Grant No. 163 ($2000) in 1958. Sampling Plans for the Acceptance or Rejection of Skid Lots of Paper. To put this project into motion there will be a meeting of the subcommittee during the 1959 TAPPI Annual Meeting. The survey will proceed in two steps: (1) a mill trial to test the instructions, and (2) a 15-mill survey which will be completed within the year. Complete analysis of the data may run into 1960.

Testing Division (C. E. Brandon, General Chairman)

Chemical Methods Committee (E. S. McColley, Chairman) Grant No. 129 ($2900) in 1957. Disperse Cellulose Viscosity. This project has been completed, and a report will soon be issued. The work was done at The Institute of Paper Chemistry.

Precision Committee (C. A. Bicking, Chairman) Grant No. 135 ($3000) in 1957. Statistical Study of the Precision of Pulp and Paper Testing Procedures. Six phases of this project have been active during 1958. Five were concerned with the collection of data and their analysis, and the other was for liaison with the project on smoothness and compressibility as related to printability, financed by another grant. One paper on the results of this study was presented at the 1958 TAPPI Testing Conference. This has been submitted for publication. Another paper is scheduled for the 1959 Testing Conference. A final review of the results from the round-robin tensile strength test is expected by March 31, 1959. Round-robin basis weight tests will be planned at the 1959 Annual Meeting of the committee. These will be completed by Sept. 30, 1959. Financial statement:

Amount of grant	$3000.00
Expended during 1958	401.95
Balance (Dec. 31, 1958)	$2598.05

It is planned to undertake a new series of round-robin tests, which will be detailed at the 1959 annual meeting of the committee. Another paper is being prepared for publication in *Tappi*.

Fibrous Raw Materials Testing Committee (E. R. Schafer, Chairman) Grant No. 43 ($2500) in 1952. Species Identification of Wood and Wood Fibers. A report describing the V-notched card sorting system and the code for North American softwoods will be ready for publication in April, 1959. The TAPPI grant has been expended; work on the method in recent years has been financed with Forest Service Research funds. This investigation was carried out at the U. S. Forest Products Laboratory.

Grant No. 94 ($2000) in 1956. Dirt in Wood Chips. This project is being continued at the University of Colorado. The TAPPI grant has been exhausted and some of the work is being financed by a grant-in-aid from industry.

Paper Testing Committee (L. Price, Chairman) Grant No. 143 ($2800) in 1958. Relationship and Sensitivity of Air-Leak Smoothness Testers. This is a joint project with the Graphic Arts Committee. Some of the results of the first phase of the work were given in a paper presented at the 1958 TAPPI Testing Conference. The new statistical tool used for analyzing an interlaboratory test, was briefly mentioned. A more detailed explanation will be presented by John Mandel at the 1959 TAPPI Annual Meeting. A complete report is being prepared for publication in *Tappi*. The second phase of the work, financed in part by TAPPI, is now getting under way. Supervision is under T. W. Lashof, chairman of the Joint Task Committee, and John Mandel, who serves as consultant to the committee. Considerable time was spent in preparing the statistical tool and arranging for its programming on the IBM 704 computer. The work is done at the National Bureau of Standards.

Financial report: Charges for the initial period to Dec. 27, 1958, are divided as follows:

Personal services	$100.00
Materials	13.00
Bureau services	32.00
Total charges	$145.00

Paperboard Testing Committee (H. W. Verseput, Chairman Subcommittee for Project) Grant No. 139 ($10,000) in 1957. Investigation of Smoothness and Compressibility of Paper and Paperboard as Related to Printability. This is a joint project with the Paper Testing Committee. It was begun at The Institute of Paper Chemistry on Feb. 1, 1958. A two-pronged attack on some of the problems of determining what factors make paper or paperboard "printable" is planned. One portion is concerned with the dynamic compressibility characteristics of paper in a nip. It is thought that the nip-spreading technique, measuring apparently the void *volume*, might offer an important contribution to the understanding of printability. It has been found that the nip-spreading technique can be used to characterize surfaces over a wide range of conditions but further work must be done in this field. The samples used have also been examined by other techniques. The work to date has been largely of an exploratory nature and has been required to establish the limiting conditions within which the technique is valid. Phase A is concerned with a study of nip-spreading technique. This should now be put to work to see what knowledge may be gained through its use. This study is being carried out at The Institute of Paper Chemistry, which has agreed to match the TAPPI Grant of $10,000 to finance the project. The TAPPI Grant has been expended, and the Institute has spent $5484.82 of its own funds. The remaining $4515.18 is expected to carry the work through March, 1959.

Container Testing Committee (M. J. Clark, Chairman) Grant No. 133 ($1994.50) in 1957. Study of the Effect on Flat Crush Results of Speed of Loading, Size of Test Specimen, Type of Loading, Shape of Test Specimen, and Effect of Lateral Movement. This project was started Jan. 3, 1958, and the Container Laboratories submitted a preliminary report on March 31, 1958. The progress to date will be reviewed at the meeting of the committee during the 1959 TAPPI Annual Meeting. A task group was appointed to develop a method based on the results of the project. A statistical analysis of the data has been requested by the committee.

Financial statement: Of the original grant, $1774.50 has been paid.

PERSONAL MENTION

Items About New and Old Tappimen

New TAPPI Members

Lennart A. Aberg, Technical Assistant, Technical Service Dept., West Virginia Pulp & Paper Co., Covington, Va., a 1953 graduate of Chalmers Institute of Technology.

Adrien W. Allard, Chemist, Nashua Corp., Nashua, N. H., a 1954 graduate of the University of Connecticut.

Nils O. Arve, Technical Manager, Wifstavarfs A/B, Vivstavarv, Sweden, a graduate of Chalmers Technical University.

Hans Augustin, Research officer, Bundesforschungsanstalt fur Forst-und Holzwirtschaft, Reinbek/Hamburg, Schloss, Germany, a 1953 graduate of University of Hamburg.

Francis M. Aylward, Foreman, Oxford Paper Co., Rumford, Me.

Merrik B. Baggallay, Mill Manager, Bridgend Paper Mills Ltd., Llangynwyd, near Bridgend, Glamorgan, Wales, a 1941 graduate of Kings College, Cambridge.

Bruce C. Benedict, Group Leader, Phillips Petroleum Co., Bartlesville, Okla., a 1938 graduate of the University of Texas.

Raymond H. Berger, Staff Engineer, Alton Box Board Co., Alton, Ill., a 1953 graduate of Washington Un versity, St. Louis, Mo.

Gustav, Bergstrom, Research Project Engineer, Champion Paper & Fibre Co., Hamilton, Ohio, a 1948 graduate of the Technical College of Harnosand, Sweden.

Richard L. Blanchard, Chemist, Brown Co., Berlin, N. H., a 1942 graduate of Bates College.

Peter G. Bond, Packaging Officer, Cerebos Ltd., Willesden, London, England.

Edward S. Brazington, Technical Manager, Thomas Owen & Co. Ltd., Ely, Cardiff, Wales, a 1950 graduate of Kings College, London University.

Thomas S. Burns, Group Leader, Union Bag-Camp Paper Corp., Savannah, Ga., a 1946 graduate of Alabama Polytechnic Institute.

Angelo Buzzoni, Administrator, Cartiere Riunite Dervio & Parmigiana, Dervio (Como), Italy, a 1938 graduate of Politecnico di Milano.

Edward G. Byrne, Jr., Field Engineer, Elliott Co., Div. of Carrier Corp., Jeannette, Pa., a 1953 graduate of Stevens Institute of Technology.

Giacomo S. Calisto, Technician, Cartiere Pirinoli S.p.A., Torino, Italy. Attended the Technical University.

Francis E. Calvert, Technical Director, Protein Dept., Archer-Daniels-Midland Co., Cincinnati, Ohio, a 1932 graduate of Edison Institute of Technology.

Mario Cardolle, Perito Industriale, Industrie Chimiche Barzaghi ufo SpA, Milano, Italy, a 1933 graduate of Quinstio Sella.

Charles J. Carter, Chief Engineer, The Great Lakes Paper Co. Ltd., Fort William, Ont., Canada, a 1947 graduate of Queen's University.

Henri Charles, Chief de Fabrication, Cellulose du Rhone, Tarascar, Bouches de Rhone, France.

Franklin H. Cloud, Industrial Engineer, American Box Board Co., Grand Rapids, Mich., a 1947 graduate of Georgia Institute of Technology.

Don F. Cook, Technical Sales Director, Southern Naval Stores, Chicago, Ill., a 1954 graduate of Purdue University.

Bigelow Crocker, Jr., Mill Manager, Crocker, Burbank & Co., Fitchburg, Mass.

Albert Dauwe, Technical Salesman, Societe des Produits de Mais, Paris, France, a 1920 graduate of the Institute Chimique de Paris.

Charles L. Dickson, Plant Manager, Spaulding Fibre Co., Inc., Milton, N. H., a 1926 graduate of the University of New Hampshire.

Arthur J. Dimick, Sales Manager, Columbia Box Board Mills, Inc., Chatham, N. Y.

John M. Doering, Technical Director, Fibreboard Paper Products Corp., Sumner, Wash., a 1938 graduate of Montana State University.

John Ray Easterly, Technical Representative, A. E. Staley Mfg. Co., Decatur, Ill.

Lennart Enstrom, Resident Manager, The Swedish Cellulose Co., Munksund, Sweden, a 1950 graduate of Chalmers Institute of Technology.

John D. Florence, Sales Manager, Archer Daniels-Midland Co., Minneapolis, Minn., a 1951 graduate of the University of California, Los Angeles.

Albrecht W. Freiherr von Streit, Project Engineer, Great Northern Paper Co., Millinocket, Me., a 1955 graduate of the Technical University, Darmstadt.

Eckart H. Freiherr von Streit, Project Engineer, Great Northern Paper Co., Millinocket, Me., a 1955 graduate of the Technical University, Darmstadt.

Joseph L. Friedman, Executive Assistant, Kaiser Engineers, Oakland, Calif., a 1932 graduate of Massachusetts Institute of Technology.

Joachim Friese, Research Engineer, Consolidated Paper Corp., Grand'Mere, P. Q., Canada, a 1954 graduate of the Technical University of Stuttgart, Germany.

Max O. Funk, Engineering Specialist, Combustion Engineering, Inc., New York, N. Y., a 1936 graduate of New York University.

Marcelo Godoy, Engineer, Celulosa Argentina S.A., Zarate, Province of Buenos Aires, Argentina.

Nollie B. Guerrant, Jr., Chemist, New York & Pennsylvania Co., Inc., Johnsonburg, Pa., a 1955 graduate of Pennsylvania State University.

Harold S. Hacker, Director, Rochester Public Library, Rochester, N. Y.

Edward G. Halleck, Technician, Pulp and Paper Research, Diamond Alkali Co., Painesville, Ohio.

J. Kelvin Hamilton, Research Supervisor, Rayonier, Inc., Olympic Research Div., Shelton, Wash., a 1952 graduate of the University of Minnesota with a Ph.D. degree.

Joseph E. Hemsch, Salesman, Peter Cooper Corp., Gowanda, N. Y. Attended the University of Minnesota.

Robert L. Henderson, Sales Engineer, The Portland Co., Portland, Me. Attended Springfield College.

William T. Heyse, Mort Battery, 2nd B. G. 60th Infantry, Fort Devens, Mass., a 1957 graduate of New York State University, College of Forestry.

John P. Hollihan, Jr., Technical Service Representative, Rayonier, Inc., New York, N. Y., a 1940 graduate of the University of Minnesota.

Ralph E. Holt, Plant Engineer, Diamond Gardner Corp., Red Bluff, Calif., a 1950 graduate of Syracuse University.

R. L. Hooper, Quality Control Manager, Olin Mathieson

Chemical Corp., Ecusta Paper Div., Pisgah, Forest, N. C., a 1939 graduate of North Carolina State College.

Robert R. Howarth, Executive Vice-President, Columbia Box Board Mills, Inc., Chatham, N. Y.

Charles W. Hoyt, Treasurer, Wolverine Equipment Co., Cambridge, Mass., a 1928 graduate of Massachusetts Institute of Technology.

John D. M. Hughes, Technical Representative, Harrigan Roller Co., Inc., Baltimore, Md., a 1943 graduate of Dartmouth College.

Glen P. Huppke, Chemical Engineer, Fiber Products Research Center, Inc., Beaver Falls, N. Y., a 1947 graduate of Polytechnic Institute of Brooklyn.

Charles W. Hurley, III, Process Control Engineer, Scott Paper Co., Chester, Pa., a 1949 graduate of the University of Pittsburgh.

Robert Hutchinson, Jr., Manager, Metals Engineering Co., Natick, Mass., a 1948 graduate of Columbia University.

William H. Jackson, Assistant Marketing Manager, The Babcock & Wilcox Co., Barberton, Ohio, a 1936 graduate of Lafayette College.

Edward M. Johnson, Engineer-in-Charge, Fibre Products Laboratory, Line Material Industries, S. Milwaukee, Wis., a 1954 graduate of the University of North Dakota.

Harold Judd, Chemist, Champion Paper & Fibre Co., Hamilton, Ohio, a 1954 graduate of Eastern Kentucky State College.

Franz Kaiser, Chemist/Director, Phrix-Werke A/S, Hamburg, Germany, a 1937 graduate of the Technical University, Braunschweig, with a Ph.D. degree.

Ichiro Kawakami, Manager, Kizu Mill, Chuetsu Insatsu Seishi Co. Ltd., Toyama, Japan, a 1951 graduate of Osaka University.

Norio Kawaguchi, Mill Manager, Fushiki Mill, Chuetsu Pulp & Paper Co. Ltd., Toyama, Japan, a 1941 graduate of Kanazawa University.

Toshio Kawaguchi, Mill Manager, Honshu Paper Mfg. Co. Ltd., Kumano Mill, Wakayama Pref., Japan, a 1936 graduate of Tokyo University.

Eugene L. Kemper, Paper Coating Technician, Schmidt Lithograph Co., San Francisco, Calif., a 1956 graduate of California State Polytechnic College.

Robert W. Kennedy, Instructor of Wood Technology, Faculty of Forestry, The University of British Columbia, Vancouver, B. C., Canada, a 1955 graduate of the University of British Columbia.

Joseph F. Keyes, Pulp Mill Superintendent, North Carolina Pulp Co., Plymouth, N. C., a 1928 graduate of the University of Maine.

Kenichi Kikuchi, Chief Engineer, Oriental Photo Industrial Co. Ltd., Tokyo, Japan, a 1934 graduate of Yamagata University

John H. Kila, General Manager, Angel Soft Tissue Co., Inc., Thomson, N. Y., a 1948 graduate of the Academy of Arts and Sciences.

David J. Kingsbury, Mill Engineer, The Portland Co., Portland, Me. Attended Boston University.

Dieter Klenk, Technical Director, Hakle-Werke, Mainz/Rhein, Germany, a graduate of the Polytechnic Institute, Munich.

Ernst H. Krauss, Manager, H. C. Sleigh Ltd., Melbourne, Australia.

Ortwin Kullmann, General Manager, Thomas Josef Heimbach G.m.b.H. & Co., Duren/Rhld., Germany, a graduate of American Institute for Foreign Trade.

James M. Kyte, Jr., President, Coated Products, Inc., Middlesex, N. J., a 1950 graduate of Dickerson College.

Albert C. Lamoureux, Head, Chemical Research Dept., Dennison Mfg. Co., Framingham, Mass., a 1926 graduate of Massachusetts Institute of Technology.

Frederick T. Lawrence, Chemist, Louis Dejonge Co., Fitchburg, Mass., a 1951 graduate of Colorado State University.

Clyde W. Leaf, Staff Consultant, Wyandotte Chemicals Corp., Wyandotte, Mich., a 1941 graduate of Columbia University.

M. E. Lerner, Editor, *Adhesives Age,* New York, N. Y. Attended St. Johns University.

Gilbert I. Liebenow, President, Box-Print Machinery Co., Inc., Chicago, Ill. Attended Georgetown College.

Ville I. Luostarinen, Board Mill Superintendent, Enso-Gutzeit Oy, Kaukopaa, Finland, a 1953 graduate of the Technical University, Helsinki.

Lincoln G. Maclise, Supervisor, The Dow Chemical Co., San Francisco, Calif., a 1941 graduate of the University of California.

Hugh M. MacTurk, Sales Manager, John & E. Sturge Ltd., Birmingham, England, a 1944 graduate of the University of Bristol.

Jerome C. Marquardt, Senior Process Engineer, Marathon Div., American Can Co., Menasha, Wis., a 1951 graduate of the University of Wisconsin.

Richard H. McDowell, Technical Director, Alginate Industries Ltd., London, England, a 1932 graduate of Jesus College, Oxford.

James G. Meier, Manager, Archer-Daniels-Midland Co., Minneapolis, Minn., a 1942 graduate of the University of Minnesota.

Otto Merckens, Managing Director, Thomas Josef Heimbach G.m.b.H. & Co., Duren/Rhld., Germany, a graduate of the University of Leeds, England.

Thomas C. Morganstern, Technical Representative, A. E. Staley Mfg. Co., Decatur, Ill., a 1956 graduate of the Babson Institute of Business Administration.

Donald C. Morris, Technical Service Engineer, The Champion Paper & Fibre Co., Hamilton, Ohio, a 1957 graduate of the University of Cincinnati.

Kimihiko Nakaya, Manager, Nomachi-Fushiki Mill, Chuetsu Pulp & Paper Co. Ltd., Toyama, Japan, a 1932 graduate of Korean Mining Training School.

Robert H. Neisel, Section Chief, Materials Testing Section, Johns-Manville Products Corp., Manville, N. J., a 1939 graduate of the College of the City of New York.

Janis Niedra, Chemist, Armstrong Cork Co., Beaver Falls, Pa., a 1942 graduate of the University of Latvia.

Nils Erik Nyberg, Chief Engineer, Dynas AB, Vaja, Sweden. Attended Stockholm University.

Scalvi Ottorino, Chief of Production, Cartiere di Verona SpA, Milan, Italy, a 1950 graduate of Turin University.

Claude E. Patch, Treasurer, Morton C. Tuttle Co., Boston, Mass., a 1902 graduate of Massachusetts Institute of Technology.

William E. Patte, Technical Director, Garden City Paper Mills Co. Ltd., Merritton, Ont., Canada, a 1940 graduate of the University of Toronto.

Russell H. Pentecost, Instrument Superintendent, Oxford Paper Co., Rumford, Me., a 1945 graduate of Worcester Polytechnic Institute.

Thomas H. Prior, Plant Engineer, Arch Bilt Corp., Maspeth, L. I., N. Y. Attended New York University.

Mohammed Rafiuddin, Production Manager, Karnaphuli Paper Mills Ltd., Chandraghona, Chittagong Hill Tracts, E. Pakistan, a 1940 graduate of Osmania University.

James D. Ramer, Librarian, Engineering and Physical Sciences Library, University of Maryland, College Park, Md., a 1957 graduate of Columbia University.

Howard A. Raymond, Jr., President, Resi-Chem Corp., Swanton, Ohio.

Eric F. Reid, Technical Director, The Paterson Engineering Co. Ltd., London, England, a 1923 graduate of Sidney Sussex College.

Albert F. Reilly, Research Director, O-cel-o Dept., General

Mills, Inc., Tonawanda, N. Y., a 1943 graduate of Williams College, with a Ph.D. degree from the University of Buffalo in 1950.

Rolf B. Reinhall, Chief Engineer, AB Defibrator, Stockholm, Sweden, a 1944 graduate of Harnosand Polytechnicum.

George E. Relyea, Paper Mill Engineer, Personal Products Corp., Paper Div., Milltown, N. J.

Charles L. Riemer, Chief Inspector, Champion Paper & Fibre Co., Hamilton, Ohio.

John S. Robinson, Sales Representative, Becco Chemical Div., Food Machinery & Chemical Corp., Buffalo, N. Y. Attended the University of Buffalo.

Jerome M. Rose, Student, New York State College of Forestry, Syracuse, N.Y.

Edward T. Ruffin, Assistant Manager of Research, Masonite Corp., Laurel, Miss., a 1933 graduate of Mississippi State College.

John H. Rusch, President, Chemical Cleaning, Inc., New Orleans, La., a 1945 graduate of Case Institute of Technology.

Murray Rushmore, Jr., Partner, Moore & Munger, New York, N. Y., a 1948 graduate of Yale University.

Bertram Sayer, Salesman, Rohm & Haas, Philadelphia, Pa., a 1957 graduate of Syracuse University.

Kotaro Saito, Mill Manager, Honshu Paper Mfg. Co., Nakatsu Mill, Nakatsugawa City, Gifu Pref., Japan, a 1928 graduate of Tokyo College of Technology.

Adolf Schmidt, Design Engineer, J. W. Sanders G.m.b.H., Berg. Gladbach, Germany, a 1951 graduate of the Engineering College, Darmstadt.

Clinton B. Schoch, Supervisor, Testing and Consulting Laboratory, Pitney-Bowes, Inc., Stamford, Conn., a 1950 graduate of the University of Connecticut.

Carl T. Schueren, Product Engineer, Standard Oil Co. (Ohio), Cleveland, Ohio, a 1934 graduate of Fenn College.

Hitoshi Shimura, Manager, Honshu Paper Mfg. Co., Iwabuchi Mill, Shizuoka Pref., Japan, a 1927 graduate of Waseda University.

Kohei Shinoda, Head, Development Dept., Toa Gosei Chemical Industries Co. Ltd., Tokyo, Japan, a 1935 graduate of Tokyo Pharmacy College.

Rene Silva, Chief Design Engineer, Continental Can Co., Robert Gair Div., New York, N. Y., a 1930 graduate of the Catholic University of Chile.

Kenneth D. Smith, Technical Service Engineer, The Champion Paper & Fibre Co., Hamilton, Ohio, a 1958 graduate of Western Michigan University.

H. Donald Snyder, Chief, Microbiological Laboratory, Troy Chemical Co., Newark, N. J., a 1948 graduate of Rutgers University.

Roland J. Stanton, Chemical Engineer, Ketchikan Pulp Co., Ketchikan, Alaska, a 1953 graduate of the University of Washington.

Henry A. Stikes, Jr., Plant Engineer, St. Joe Paper Co., Port St. Joe, Fla., a 1950 graduate of Alabama Polytechnic Institute.

Henry L. Stoltz, Production Superintendent, R-W Paper Co., Longview, Wash.

Melvin E. Stonebraker, Sales Service Manager, Archer-Daniels-Midland Co., Cincinnati, Ohio. Attended the University of Cincinnati.

George Thomson, Assistant Director of Research, Fabric Research Laboratories, Inc., Dedham, Mass., a 1921 graduate of Massachusetts Institute of Technology with a Ph.D. degree.

Leslie E. Towle, Plant Manager, Spaulding Fibre Co., Inc., N. Rochester, N. H., a 1954 graduate of Massachusetts Institute of Technology.

George Treier, Chemist, P. H. Glatfelter Co., Spring Grove, Pa., a 1958 graduate of New York State College of Forestry.

Krishnaswami Venkatarman, Director, National Chemical Laboratory, Poona, India.

Giuseppe Viola, Technical Manager, Sindacato Cellulosa Pomilio, Rome, Italy, a 1950 graduate of Rome University with a D.Ch.E. degree.

Conrad T. Waldie, Assistant Technical Director, Brown Co., Berlin, N. H., a 1943 graduate of the University of Pennsylvania.

Charles E. Walker, District Sales Manager, Resi-Chem Corp., Swanton, Ohio.

Leonard M. Wylie, Technical Advisor, Tennessee Corp., Research and Development Dept., College Park, Ga., a 1951 graduate of the Georgia Institute of Technology.

TAPPI Notes

Abdul-Medjid Ayroud, formerly with the Pulp and Paper Research Institute of Canada, is now a senior research chemist with the Consolidated Paper Corp. Ltd., Grand'mere, P. Q., Canada.

G. Sterling Bailey is now Technical Director of the North Carolina Pulp Co., Plymouth, N. C.

Gunther H. Baldauf, formerly of the Ecusta Paper Co., is now Research Manager for the Allied Paper Corp., Kalamazoo, Mich.

Louis O. Barber, formerly of J. C. Baxter Co., is now General Superintendent of Zimmer Paper Products Co., Indianapolis, Ind.

Charles A. Bassemir, formerly of O. L. West Co., is now with Connelly Containers, Inc., Pencoyd, Pa.

Martin W. Bates, formerly of Crossett Paper Mills, is now Plant Engineer for Bowaters Carolina Corp., Catawba, S. C.

George W. Broughton, formerly Research Chemist with Ludlow Paper, Inc., is now the Kupfer Bros. Co., Northbridge, Mass.

Duncan S. Brown is now Vice-President is Charge of Manufacturing for The Diamond Gardner Corp., Middletown, Ohio.

Joseph C. Brown, formerly of Weyerhaeuser Timber Co., is now General Manager of North Carolina Pulp Co., Plymouth, N. C.

Edward W. Carpenter, Sales Engineer of Industrial Nucleonics, has been transferred from South Hadley Falls, Mass., to Columbus, Ohio.

Punya Brata Chaudburi, formerly Chemical Engineer for Boving & Co., is now with A/B Karlstad Mekaniska Werkstad, Karlstad, Sweden.

J. Raymond Curtis is now Director of Operations Research for Scott Paper Co., Chester, Pa.

Ralph M. DeMarco, formerly of the American Can Co., is now a Research Chemist for Kimberly-Clark Corp., Neenah, Wis.

Theodore E. Detcher, formerly of Chemical Linings, Inc., is now Sales Manager for John W. Rouse Construction Corp., Gouveneur, N. Y.

John F. Donahue, of the Gair Div. Continental Can Co., has been transferred from Tonawanda, N. Y., to Los Angeles, Calif.

Harry L. Dyer, formerly Chemist for the Brown Co., is now an Assistant Editor of the *Paper Trade Journal,* New York, N. Y.

Philip H. Emery, Jr., formerly of the University of Maine, is now a Student at The Institute of Paper Chemistry, Appleton, Wis.

Raymond L. Evans, formerly of Kelco, Inc., is now a Project Engineer with the Manchester Machine Co., Middletown, Ohio.

Thomas E. Flanagan is now Superintendent of The Wax Division, The KVP Co., Kalamazoo, Mich.

George D. Fronmuller, formerly of the Commonwealth Color & Chemical Co., is now Vice-President of Comcolloid, Inc., Bronx, N. Y.

Peter E. Fuerst, formerly Chemical Engineer for the

Forming Machine Co. of America, Inc., is now with the General Electric Co., Coshocton, Ohio.

Martin Gale, formerly of The Borden Chemical Co., is now Technical Director of the H. B. Fuller Co., Linden, N. J.

Karl F. Gustafsson, formerly of Svenska Cellulose A/B, is now Mill Manager of A/B Klippans Finpappersbruk, Drev, Sweden.

Carl A. Gyllenhoff, formerly of Leje & Thurne, A/B, is now Resident Manager of Nissastrours Board & Pulp Mills, Johansfors, Sweden.

Ashton I. Hamilton, formerly of Hollingsworth & Whitney Co., is now Paper Mill Technical Service Group Leader, Oxford Paper Co., Rumford, Me.

Herbert D. Hamilton, formerly of the Riegel Paper Corp., is now Mechanical Engineer for The Mead Corp., Chillicothe, Ohio.

Walter L. Hardy, formerly of Foster D. Snell, Inc., is now with International Minerals & Chemical Corp., Skokie, Ill.

Harold Holden, formerly of the Eastern Corp., is now President and General Manager of the Gilman Paper Co., New York, N. Y.

Gordon C. Inskeep, formerly of Process Research Inc., is now Assistant to the Director of the Central Technical Department, St. Regis Paper Co., New York, N. Y.

C. Harry R. Johnson is now President and General Manager of the Consolidated Paper Co., Monroe, Mich.

Rudolf L. Kutter, formerly of the Black-Clawson Co., is now in the Sales Department of Beloit Iron Works, Beloit, Wis.

Chester G. Landes is now Technical Director of Wica Chemicals, Inc., Charlotte, N. C.

John H. Langstaff, formerly of Monsanto Canada Ltd., is now District Sales Manager of J. C. Wilson Ltd., Mt. Royal, P. Q. Canada.

James J. Larkin, formerly of the Container Laboratories, Inc., is now with Aldens, Inc., Chicago, Ill.

Niels J. Larsen, formerly of the Albany Felt Co., is now a Paper Mill Consultant, R.F.D. 3, Gt. Barrington, Mass.

Andre H. Locus, formerly Research Chemist for the Nylonge Corp., is now with Rayonier, Inc., New York, N. Y.

John M. MacBrayne is now Director of the General Services Division, Union Bag-Camp Paper Corp., New York, N. Y.

Cecil E. MacDonald, formerly of the Canadian International Paper Co. Ltd., is now Assistant to the President of the Riordon Sales Corp., New York, N. Y.

William D. Major, formerly of the Container Corp. of America, is now Assistant Technical Director of The West Virginia Pulp and Paper Co., Covington, Va.

George J. Miles, formerly of Swenson Evaporator Co., is now President of W. P. & H. Inc., Sanford, Fla.

Francis X. Nerney is now Southeastern Sales Manager of the Becco Chemical Division, Food Machinery & Chemical Corp., Atlanta, Ga.

Joseph A. Pascale, formerly sales manager for Wilson Wire Works, Inc., is now with American Wire & Fabrics, Inc., Hackensack, N. J.

Robe V. Pennington, formerly with Condi Engineering Corp., is now an Engineer with Owens-Illinois Glass Co., Mill Division, Jacksonville, Fla.

Merrill Robinson is now Manager of the Grays Harbor mill, Weyerhaeuser Timber Co., Cosmopolis, Wash.

Jose L. Roldan, G., formerly of Fabrica de Celulosa el Pilar S/A., is now a Consultant in Mexico City, Mexico.

Willard F. Schroeder, formerly of Mallory Sharon Metals Corp., is now Technical Service Supervisor, U. S. Industrial Chemicals Corp., Ashtabula, Ohio.

Ernest E. Sellers, formerly with Buckeye Cellulose Corp., is now with the Charmin Paper Products Co., Green Bay, Wis.

Robert W. Shaw, formerly Student at Western Michigan University, is now Project Supervisor for Watervliet Paper Co., Watervliet, Mich.

Edwin I. Stearns, of Dyes Dept., American Cyanamid Co. has been transferred from Chicago, Ill., to Bound Brook, N. Y., as Technical Manager.

Everett A. Strain, formerly of U. S. Gypsum Co., is now with Ethicon, Inc., Somerville, N. J.

Sinclair P. Strayer is now Assistant to the General Superintendent of the St. Regis Paper Co., Tacoma, Wash.

C. Edward Taylor is now Assistant Paper Mill Superintendent of Georgia-Pacific Paper Co., Toledo, Ore.

R. Tourangeau, formerly of The E. B. Eddy Co., is now a paper mill consultant in Ottawa, Ont., Canada.

Edward H. Tutun, formerly of Bonded Fibers, Inc., is now with the Dewey & Almy Chemical Division, W. R. Grace & Co., Adams, Mass.

Gordon L. Waasdrop is now Superintendent of the Baryton Division, Eastman Kodak Co., Rochester, N. Y.

John R. Wilson, formerly Superintendent of the Hinde & Dauch Paper Co. of Canada, Ltd., is now with Grace & Cia, Arecibo, Puerto Rico.

* * *

Clyde Davis has succeeded *Nathaniel G. McLean* as the official corporate representative of Finch, Pruyn & Co., Glens Falls, N. Y., in the Technical Association.

* * *

Paul W. Clark has succeeded *Jack S. Morgans* as the official representative of Allis-Chalmers Mfg. Co., Milwaukee, Wis., in TAPPI.

Herbert A. Wormwood has succeeded *Charles W. Bobb, Jr.,* as the official representative of Knox Woolen Co., Camden, Me., in TAPPI.

Jack F. Wright has succeeded *Harris B. Fehn, Jr.,* as the official representative of the National Aniline Division, Allied Paper Corp., New York, N. Y., in TAPPI.

Robert V. Prive has succeeded *Albert O. Dyson* as the official representative of Nichols Engineering & Research Corp., New York, N. Y., in the Technical Association.

William F. McDonald is now the official representative of U. S. Industrial Chemicals Co., Tuscola, Ill., in TAPPI.

Industry Notes

PRODUCTION

Paper and board production during November amounted to 2,645,344 tons. This was 4% above the 2,538,542 tons produced in November a year ago. Paper production amounted to 1,151,191 tons, which was 4% above 1,112,025 tons produced in November a year ago. The output of paperboard during this month was 1,239,280 tons, reflecting a 5% increase above the production of 1,183,840 tons reported for November, 1957.

Pulpwood receipts at the pulp mills in November amounted to 2,871,201 cords, with consumption at 3,065,766 cords. Month-end inventories decreased to 5,918,261 cords.

Consumption of fibrous materials other than pulpwood, totaled 811,334 tons in November, compared to 774,019 tons in November, 1957. Inventories of 905,482 tons at month's end reflected a 16% increase over end of October inventories. Consumption of waste paper amounted to 726,910 tons, as compared to the 684,642 tons consumed in November a year ago.

Wood pulp production during November amounted to 1,909,115 tons as compared to 1,851,285 tons produced in November a year ago.

Wood pulp consumption in the paper and board mills during November amounted to 1,963,870 tons, compared to the 1,822,834 tons consumed in November a year ago.

Wood pulp inventories at the end of November at the paper and board mills, amounted to 529,546 tons, as compared to 533,838 tons reported at the end of October. Month-end

stocks of the pulp mills were 277,404 tons, as compared to 271,979 tons reported at the end of October.

Forest Service

Fifteen million acres of forest land! That's the extent of "Penn's Woods" today—much less than three centuries ago when William Penn received the land from Charles II of England. Still, even now, it's a figure that represents more than half of Pennsylvania's land area.

This is but one fact brought out in a 46-page, illustrated booklet, "The Timber Resources of Pennsylvania." The survey was made and published by the Forest Service's Northeastern Forest Experiment Station in cooperation with the Pennsylvania Department of Forests and Waters.

Announcement of publication is made by Ralph W. Marquis, director of the Northeastern Station.

Copies of "The Timber Resources of Pennsylvania" are available from the Northeastern Forest Experiment Station, 102 Motors Ave., Upper Darby, Pa.

P. S. Bolton

Philip S. Bolton is retiring after 16 years as Research and technical director of the Robert Gair Co., the predecessor of the Continental Can Co.'s Robert Gair Paper Products Group. He joined the Robert Gair Co. in 1943 to establish the research department of this company. In 1949 he assumed the added duty of technical director and held both positions until reaching the company's retirement age in 1958. Since then he has been special assistant to the general manager of engineering, research, and development of the Robert Gair Paper Products Group.

Mr. Bolton has been a member of TAPPI since 1917 and this year has completed a 3-year term on its Executive Committee. He is also a member of the Paper Mill Superintendents' Association, the Technical Section of the Canadian Pulp & Paper Association, and the American Chemical Society. He is a graduate of the University of Maine and has been keenly interested in the education of men for the pulp and paper industry. He is a member of the Executive Committee of the University of Maine Pulp and Paper Foundation, and is co-ordinating editor of the college textbook of pulp and papermaking being sponsored by TAPPI.

Amylomaize

Development in research quantities of a new type of corn with extraordinary possibilities in the production of new types of starches with application in many industries, and of economic benefit to the nation's corn growers, was announced today by National Starch Products Inc., and American Maize-Products Co., co-venturers in the project.

At a news conference in Chicago, the chief executive officers and research directors of the companies said that the project, in being since 1953 with Bear Hybrid Corn Co., Decatur, Ill., and the United States Department of Agriculture Northern Research Laboratory, Peoria, Ill., is a dramatic demonstration of cooperative investigation and research between private enterprise and government.

They said that new avenues of research now being explored may be regarded as a scientific breakthrough of economic importance to corn growers, industries which will be able to improve present products and develop new ones through the chemical processing of starch from the new type of corn, and the ultimate corn requirements and sales volumes of American Maize-Products and National Starch Products.

President Theodore Sander, Jr., and Research Director James W. Evans of American Maize, and Chairman Frank K. Greenwall and Vice-President—Research C. G. Caldwell of National Starch, said that preliminary research estimates of application of starch manufactured from the new corn, known as amylomaize, indicate the following possibilities in the near future:

1. Use in water-soluble transparent film wrapping material for frozen foods, meats, and other edible products as an advance in "built-in-maid service." Thus the housewife will be able to cook her meals without removing the wrappings, since the amylomaize wrapping materials will dissolve in the utensils as the contents are cooked. Since the film is made from corn, it becomes completely digestible when dissolved.
2. Use as a packaging material for water-dispersible products such as detergents, dyes, insecticides, and industrial chemicals as replacement for the more expensive water-soluble synthetic films now used.
3. Use in nonwater-soluble types for the coating and surface treatment of paper and paper products.

Looking into the research and product crystal ball, the executives of the corn refining companies said there are other fascinating opportunities which it is believed intensive independent laboratory activity by the two companies may bring about.

These include

1. Use of new starches as an integral part of paper.
2. Use as a permanent finish for fabrics.
3. Use in low-cost fabrics made from a combination of cotton and cornstarch.
4. Use in woodlike structural materials such as wall board and building board.

The company executives said that the economic appraisals by their research teams of immediate and future potentialities are suggested by the similarity of the new amylose and cellulose. Currently, they said, the amylose content of starch from the newly developed corn is 55% and the starches show superior performance to previous starches in all uses where film formation is required. These requirements are mainly in textile sizes, paper coatings, adhesives, paper, and packaging material.

As the amylose content of the starch approaches 100% as a result of the genetic research activities now underway, it was indicated, product applications will be expanded.

The conferees said: "We are confident that many uses will be found for high amylose starches. At first the product will move as a specialty item, but as agronomic factors are worked out, and the application program gains momentum, volume will be increased. This starch has characteristics different from those of starches now being produced. This assures new applications which will expand the potential use of the nation's corn crop."

Pollution Abatement

The pulp and paper industry has made "significant gains" in reducing pollution of the nation's waterways through in-plant processing of its waste products, the 51st Annual Meeting of the American Institute of Chemical Engineers was told in Cincinnati December 10.

This was revealed by H. W. Bialkowsky and J. C. Brown of the Weyerhaeuser Timber Co. in a paper, "Pollution Abatement in the Pulp and Paper Industry by Process Changes." Mr. Bialkowsky is the company's director of research in the pulp division, and Mr. Brown is manager of the Grays Harbor mill.

They pointed out that "the surest means of in-plant waste control for spent pulping liquors is a recovery system which will reclaim the cooking chemicals and destroy the organic B.O.D. (biological oxygen demand) load by combustion."

"During the past decade," they said, "while there have been extremely large increases in productive capacity in the pulp and paper industry, there have been corresponding significant gains in the reduction of unit pollution loads and in the management of our natural waterways. The kraft process has had the largest expansion and with refinements and process changes in washing, evaporation, recovery furnace design and operation, the recovery efficiency, and the reduction of organic pollution loads are well over 90%. Efforts by individual companies, and the combined talents working together have the common objective of protecting our water

resources by abating pollution and by proper water management."

Some idea of the magnitude of the waste disposal problem of the pulp and paper industry can be gained from the fact that the wood pulp capacity of the United States has increased at an average of 1.1 million tons per year since 1946; the 1956 production was more than 22 million short tons for the manufacture of paper and paperboard, they pointed out. The total amount of wood pulp used by the paper and paperboard industries and for textile fibers, cellophane, lacquers, etc., increased from 12 million tons in 1946 to 26 millions tons in 1957. Of this the sulphate or kraft capacity rose from $5^1/_2$ million tons in 1946 to $13^1/_2$ million tons in 1957.

The United States has an annual per capita consumption of 412 lb. of paper and paperboard, the greatest in the world. The communist block countries consume 13.8 lb. per person, and the free nations, outside the United States, 65.9 lb.

Riegel

Riegel Paper Corp. has announced the appointment of A. J. Strauss to the newly created position of director of purchases. He will report to R. L. Kerridge, vice-president, and administer policy on purchasing and its effect on inventory control, and trade relations for all divisions of the corporation. His office will continue to be located at the Milford, N. J. mill.

Harry L. Singley, assistant purchasing agent, will assume responsibility for over-all administration of the Purchasing Department for the New Jersey division.

Buckeye

The Memphis pulp plant of the Buckeye Cellulose Corp. has set a new world's record for the pulp and paper industries by operating since Jan. 22, 1956 without a lost-time accident. This feat surpasses the former industry record of 3,770,086 man-hours, which was set several years ago by the Dixie Cup Co. at Easton, Pa. In recognition of this accomplishment, the Buckeye plant will receive a National Safety Council Award of Honor.

At a plant safety celebration, Charles A. Montague, Jr., Plant Manager, congratulated the employees on their new safety record. He pointed out that if the Buckeye plant had operated at the industry average during the period covered by the award, 24 employees would have suffered lost-time accidents and three employees would have suffered death or permanent disability. He also stated that in view of Buckeye's safety record, employees were safer at work than they were in their own homes. He asked for continued cooperation in keeping the Buckeye plant as the industry's safest and set a new goal of 5 million man-hours. The Buckeye plant has previously set two world's records for the pulp industry.

Each of the 580 employees will receive an onyx handled letter opener from Buckeye in recognition of his contribution to the safety record. This letter opener adds to a desk set started at a former world safety record celebration.

Safety is part of the industrial relations work headed by E. R. Stevens. Obed Windham is plant safety engineer.

On June 13,1958 Buckeye set the World's record for the pulp industry with 3,181,783 man-hours. This new record is an extension of the pulp record but covers both the pulp and paper industries.

St. Regis

St. Regis Paper Co. announces that it has agreed to purchase a 20% interest in the Brazilian firm, Companhia Industrias Brasileiras Portela S/A which operates a paper mill at Jaboatão near Recife in the State of Pernambuco. The mill has a capacity of 1500 metric tons monthly of paper and board.

Through this investment, St. Regis, which operates two multiwall bag plants in Brazil, one at São Paulo and one at Recife, will be provided with an added paper supply source for the Brazilian plants.

National Vulcanized Fibre

Directors of National Vulcanized Fibre Co., Wilmington, Del., and Parsons Paper Co., Holyoke, Mass., have approved a plan under which National will acquire the business and assets, subject to liabilities, of the New England paper company.

A joint announcement by Eugene R. Perry, president of National, and Edward P. Bagg, Jr., president of Parsons, said the acquisition will be effected by the exchange of 76,000 shares of National's common stock for the outstanding common stock of Parsons. The paper company has approximately 200 stockholders and is traded over-the-counter. National's common stock, of which 567,000 shares are presently outstanding, is listed on the New York Stock Exchange and is currently quoted at about $13.50.

The announcement adds that the plan will be submitted to Parsons' stockholders at an early meeting. When the transaction is completed, the paper company will become the Parsons Paper Division of National Vulcanized Fibre. No changes are contemplated in personnel, products or sales policies.

Cornell

Two firms prominent in the Midwest packaging and container field announced jointly that they have combined forces in a corporate merger. Cornell Paperboard Products Co., Milwaukee, has acquired the Rathborne, Hair & Ridgway Box Co. through an exchange of stock.

Cornell Paperboard Products Co. is a leading manufacturer of paperboard, corrugated and solid fiber shipping containers, and folding cartons, with plants at Cornell and Milwaukee, Wis., and Arlington Heights, Ill. Rathborne, Hair & Ridgway Box Co. has long been identified with the manufacture of wirebound boxes and crates and corrugated shipping containers. The firm celebrated its centennial in 1955 and maintains plants in Chicago, Ill.; Savannah, Ga.; Jackson, Miss.; and Marinqouin, La.

At the Chicago offices of Cornell, it was stated that Rathborne, Hair & Ridgway would continue to operate under its present name and management as a wholly-owned subsidiary. Other wholly-owned subsidiaries of Cornell are Carton Craftsmen, Inc. of Cicero, Ill., manufacturers of folding cartons, and Superior Paper Products Co. of Marion, Ind., manufacturers of paper plates.

Scott

Details of a unique process that gives paper high standards of absorbency, softness, and other properties have just been disclosed by Scott Paper Co., Chester, Pa.

Originally developed as a solution to the problem of making oil-absorbent paper for industrial wiping uses, the process also gives paper characteristics that are desirable for other applications.

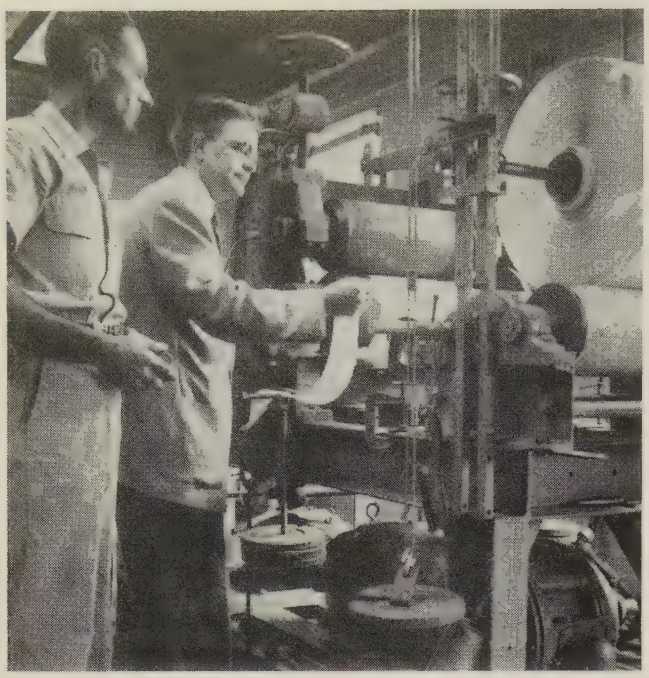
The United States Patent Office recently awarded Scott the patent covering both the "Perf-embossed" paper, and the process by which it is made.

Perf-embossed paper will have far-reaching effects on the future development of paper products for many other uses, according to Paul C. Baldwin, Scott vice-president in charge of manufacturing, engineering, research, and development.

The unusual properties given to paper in this process can be combined with other papermaking techniques to produce a wide variety of items, Mr. Baldwin said.

Perf-embossed paper is made by the patented process which both perforates and embosses the paper sheet and thus accounts for the product's name.

In addition to the Scott line of industrial wipers, other products now are manufactured by the company from types of Perf-embossed paper. These include Scott UHA (ultra high absorbency) towels, and Dura-Weve, a laminated ma-



One of the inventors of "Perf-embossed" paper, Richard W. Schutte, of Scott's research staff, strips a piece of the paper from the experimental press to examine the pattern made by the two engraved rolls being tested. Investigation at these early stages helps determine preferred roll patterns

terial consisting of two double plies of paper and rayon scrim. Guest towels, tablecloths, medical examination garments, aprons, and headrest covers are now being made from Dura-Weve.

Secret of the patented process is the use of a pair of specially engraved rolls that can simultaneously perforate, weld, and emboss the plies of paper fed between them. The process differs from ordinary embossing in that matched, mating male rolls are used. Most of the paper being processed remains uncompressed and, therefore, absorbent.

The process and the product were developed by Scott to meet the increasing need in industry for a disposable, oil-absorbent wiper. Shop towels were adequate in most instances but had a number of disadvantages. Most important, fabric wiping materials are expensive, and, to justify the initial expense, they must be used repeatedly and laundered periodically.

Shop cloths used over and over again frequently build up bacteria content or trap metallic particles in the fabric, even after laundering. Foreign matter can cause skin irritations or cuts and scratches while the person wiping his hands or face assumes he is using a clean cloth.

Recognizing the need for an economical, safe, and clean wiping material, Scott field-tested a crepe paper wiper in a large automotive plant. These wipers, however, were too flimsy or dense to soak up machine oils. These flat sheets also gave little protection to the workers. The problem then resolved itself to development of a paper wiper with these characteristics:

1. Ability to absorb oil.
2. Ability to hold oil after it is absorbed.
3. Positive ply welding to prevent the plies from separating.
4. Bulk, or "loft," to give sufficient protection to workers' hands.
5. Softness, or moldability, to allow effective wiping of irregular shaped objects.

Exhaustive tests were conducted, one of which showed that flat paper had remarkable oil absorbency characteristics. Scott research found that the holes in the paper attracted oil by capillary action.

Various puncturing devices were used to perforate high wet strength industrial papers but without much success. Happily, one of the inventors tried pressing this type of paper between two sheets of heavy window screening, and so produced the first successful Perf-embossed paper. The resulting paper had the following properties:

1. Improved oil absorbency resulting from increased capillarity.
2. Good oil capacity due to the uniformity and depth of depressions which act as "reservoirs" for absorbed oil.
3. Good adhesion between the several plies of the product.
4. Highly increased bulk resulting from the thousands of crests and depressions in the paper plies.
5. Improved wiping surface for soaking up oils, dirt, and extraneous foreign matter.

Subsequently, development work led to the attachment of wire screens to hand-operated wheels which provided the necessary backing pressure as paper was fed between them.

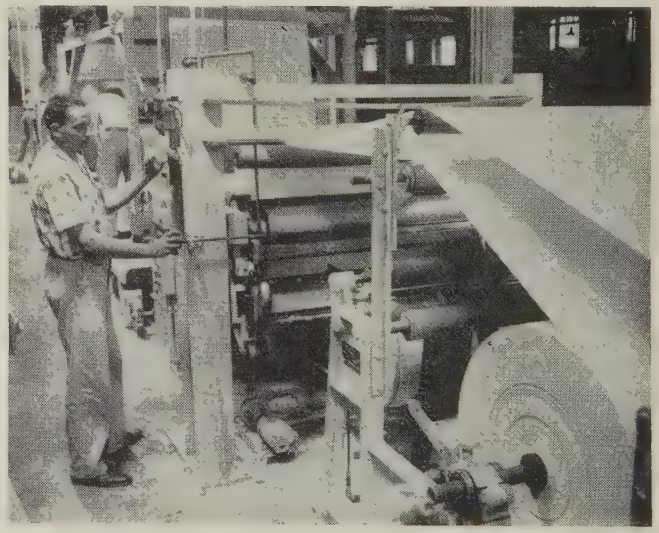
Calendar rolls covered with wire screening were then tried on a pilot plant basis. Later, engraved rolls were developed and put into full scale use. Paper produced on the engraved rolls have substantially greater oil-absorbent properties than that made on the wire-covered calendar rolls, due to refinements made in pattern design. This method also is conducive to high-speed production.

Engraved rolls used in the process give paper high cross-directional stretch, a feature that has been the goal of numerous experiments in the paper industry for many years. Paper that has equal stretch and strength in all directions has greater functional versatility.

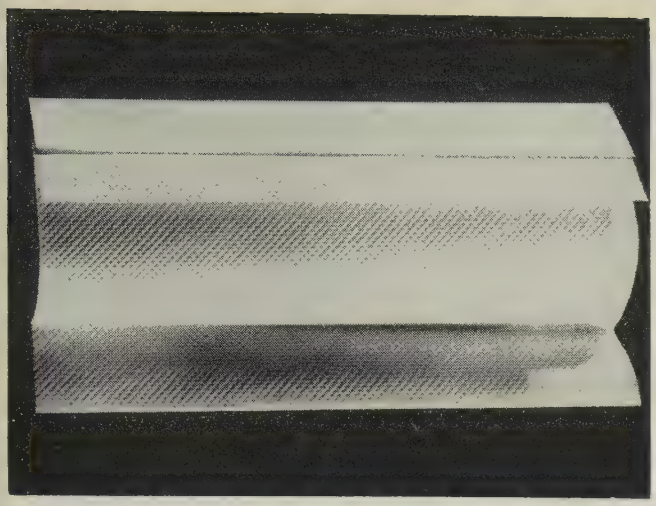
Each wire-design pattern engraved on mated sets of rolls is essentially the same—the high areas of one roll extend into low areas of the other. As paper passes between the rolls, depressions are formed on each side. These become the crests, or nodules, on the opposite side of the paper. Thus, both surfaces of the paper are formed into a nubby texture.

In ordinary embossing, fibers of paper are compressed and surface areas become stiff and nonabsorbent.

Key to the success of the Scott process, however, is the fact that the only areas of the paper compressed by the engraved rolls are the sloping sides of the raised bumps, or crests. The top of the crests and the bottom of the cuplike depressions between them retain their original softness and absorbency.



"Perf-embossed" paper for Scott Dura-Weve is processed on this production unit by feeding plies of paper between the engraved rolls. The operator shown here is manipulating the draw control on the feed rolls to coordinate the rates of speed for the two plies. In this process, the parent roll of paper is 43 in. wide



Close-up of a Scott ultra high absorbency (UHA) towel showing its "Perf-embossed" pattern

Various sets of matched engraved rolls are designed and the machine can be adjusted to work the paper to various degrees in the sloping areas of the crests. The fibers in these areas either can be perforated, ruptured, compressed, or stretched, depending on the type of Perf-embossed paper being produced.

Scott wipers, for example, have relatively large apertures to increase their oil absorbency feature.

The perforations in paper used for Scott UHA towels are not so large, because oil absorbency is not the critical need. The process, however, does impart other properties required for a paper towel. These include softness, porosity, stretch in all directions, bulk, and textured appearance.

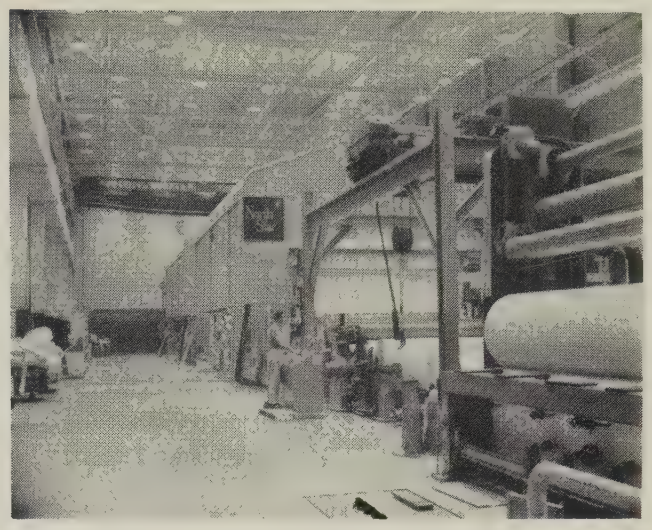
With the development of this process to produce Perf-embossed paper, Scott feels it has solved many of the problems that have confronted the paper industry in the production of economical products for home and industry. Perhaps the most significant, according to Scott executives, is the incorporation in paper of two characteristics previously believed to be incompatible: strength and softness.

Oxford

At a meeting held January 19 at the Sheraton-East Hotel in New York for approximately 150 of its distributors salesmen from the New York area, Oxford Paper Co. launched its completely new line of North Star coated papers. The new line, comprising both letterpress and offset papers, in high-gloss and dull finish, is the first complete line of top-quality coated papers produced by the trailing blade process.

"The trailing blade method of coating papers," said Harold M. Annis, vice-president, research and development, of Oxford, "is the greatest advance in papermaking in more than 20 years. It produces a levelness of surface that cannot be equalled by conventional coating methods. We believe the levelness obtained on the trailing blade, together with the fact that the surface requires less supercalendering, produces a sheet of paper that looks better and prints better than any conventionally coated paper."

North Star coated papers are the result of seven years of development and an investment of over $6.5 million dollars. The North Star Coater, located at the Rumford, Maine mill, is an off-the-machine coater for greater flexibility and speed. It is wide enough to take base paper from any machine in the mill. The coater is designed to run at speeds ranging from 200 to better than 2000 f.p.m. Supplementing the North Star coater, Oxford has installed additional facilities and equipment for roll storage, trimming, mechanical sheet inspection, and carton and skid packing. In addition, "C" machine, one of the largest paper machines at Rumford, was completely rebuilt in 1957 to serve as a primary source of coating base paper for the North Star coater.



The North Star Coater, giant new trailing blade coater, recently installed by Oxford Paper Co., Rumford, Me.

"North Star coated papers will be distributed through stocking merchants only," said Andrew M. McBurney, vice-president, sales. "They will be sold under the advertised brand names, Polar, Mainefold, and Maineflex. We are beginning to ship paper to our stocking merchants the week of Jan. 19, 1959. We are introducing North Star coated papers in New York, Chicago, and Boston the same week, and will follow through in other major cities immediately thereafter."

The Rust Engineering Co. has been awarded a design and construction contract for a major portion of a $15,000,000 kraft pulp mill program by the Oxford Paper Co., Rumford, Me.

A new softwood kraft mill with a capacity of 175 tons of pulp a day will be erected with other new facilities including a chlorine dioxide bleaching system for short and long fiber pulp, a 300-ton per day chemical recovery plant and an addition to the existing hardwood kraft mill to increase production from 250 to 350 tons a day.

The improved quality pulp from the new softwood kraft mill and the increased production of the hardwood kraft mill will permit Oxford to utilize more completely and economically the wood species available in Maine and at the same time to shut down its two existing sulphite mills. The elimination of sulphite pulp manufacturing will remove the principal source of river contamination from pulp and paper operations in the Rumford area.

Clupak

A license agreement has been signed by Canada Paper Co. and Clupak, Inc. to permit the Canadian company to manufacture stretchable paper and to use the trademark "Clupak," Gerald E. Amerman, Clupak president, announced today. The first installation in Canada will be on a paper machine at the Windsor Mills, Quebec, plant of Canada Paper.

This is the first Canadian licensee of this new process, which is primarily mechanical, and the principle itself is relatively simple. Actually the paper is made from regular wood pulp on a conventional paper machine. The equipment which makes Clupak paper different from conventional paper is an extensible unit which can be installed as part of a standard paper machine. To the eye Clupak paper is no different from conventional paper. However, Clupak paper's built-in stretch (which can be controlled with precision) sets it apart from any other paper made today. It is this property of elasticity which makes the paper many times tougher than any conventional paper of comparable weight. Along with its toughness, Clupak paper has a different "feel" than regular paper. It is softer and more pliable and has less

"rattle"—qualities which add to its advantages in many packaging applications.

To date the company has licensed (in the United States) International Paper Co., West Virginia Pulp and Paper Co., Union Bag-Camp Paper Corp., Continental Can Co., St. Regis Paper Co. and Crown Zellerbach Corp. to make the revolutionary new paper.

Armstrong Forest

The retirement of E. O. Ehrhart at the end of this year as president of the Armstrong Forest Co., a subsidiary of New York & Pennsylvania Co., Inc., was announced December 19. He has been with the company for 43 years. Top executive responsibilities for Armstrong will be assumed by Arthur L. Bennett, vice-president.

Mr. Ehrhart has had a long and distinguished career in forestry, both inside and outside of his company. He has been intimately connected with many developments which have become standard practice in the management of woodlands and in the pulpwood industry.

Continental Can

Charles H. Day has been appointed manager of manufacturing for the Paper Container Division of Continental Can Co., it was announced by E. R. Van Meter, division vice-president.

Formerly general manager, south-central district of Continental's Central Metal Division, Mr. Day will have his new headquarters at the Paper Container Division office in Newark, N. J. He replaces George H. Barker who has been named manager of Paper Container's new plant in Three Rivers, Mich.

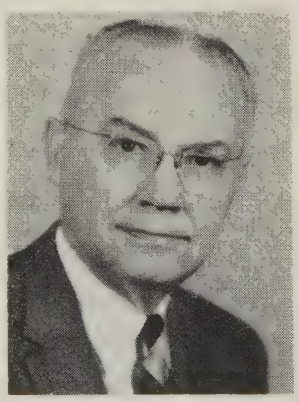
George S. Johnston, Jr., previous manager of the Three Rivers plant, has been transferred to the Robert Gair Paper Products Group of Continental Can as manager of bleached paper development. His headquarters will be in New York.

Owens-Illinois

William T. Webster, a nationally recognized authority on solving the stream pollution problems of the paper industry, retired January 1 as special projects engineer for Owens-Illinois Glass Co.

During his 43 years in the industry Mr. Webster helped engineer and develop the Wagner recovery furnace, the first spray-type furnace on the market for the recovery of chemicals used in pulp making.

Mr. Webster gained industry-wide attention between 1951 and 1954 as general manager of the mill operations of National Container Corp. with responsibility for pulp and paper mills at Jacksonville, Fla., Tomahawk, Wis., Big Island, Va., and Ontonagon, Mich.



W. T. Webster, Owens-Illinois Glass Co.

During this period he supervised the planning, construction, and start-up of National Container's new paper mill at Valdosta, Ga., whose waste treatment system has since been held up as a model for the industry.

Normal procedure is to build the mill and then worry about the waste disposal system. Mr. Webster reversed this; finding a spot some eight miles from the nearest stream, but with the right elevation, he designed a series of seven standing ponds.

The water is held for a few days or several weeks in successive ponds. Cascading streams and spillways linking the ponds aerate the waste, and bacterial action does the rest.

C. G. McLaren, O-I vice-president and general manager of the Mill Division, said, "it would be hard to overestimate Mr. Webster's contribution to pulp and papermaking."

The retired engineer, Mr. McLaren said, "literally grew up with the pulp and paper industry."

"He was a pioneer in many areas of pulp manufacturing. His particular fields of interest—chemical recovery and stream pollution—were perhaps the most vital of all the problems facing the industry at the time he began working on them."

Mr. Webster was a vice-president and a director of National Container Corp. in 1956 when National Container was merged into Owens-Illinois. Since that time his experience has been utilized in special engineering studies and projects for the company's Mill Division.

During his career Mr. Webster was associated at various times as chemist, engineer and in managerial posts with the Brown Paper Co., Dill & Collins Co., J. O. Ross Engineering Corp., St. Regis Paper Co., and, finally, National Container Corp.

Fiber Products Research Center

Paul E. LaValley has been appointed manager of mechanics research at the Fiber Products Research Center, Inc. in Beaver Falls, N. Y. Mr. LaValley has been a well-known consultant in the Boston area for the past six years in the engineering of films and coatings. Previous to this, he was technical director of the Charles Howe Corp. in Newburyport, Mass.

W. M. U.

"Principles and Practice of Coated Paper Manufacture" will again be offered to persons in and suppliers to the world's paper industry by Western Michigan University in two three-week courses during the summer of 1959, it was announced by A. H. Nadelaman, head of the paper technology department.

The classes will be run from June 21 to July 11, and from July 12 to August 1. Students will be housed in University residence halls, will eat at the University Student Center, and will have all classes in the Paper Industry Laboratories.

The classes are designed to offer a broad by detailed view of the entire coating industry, including basic principles and description as well as observation of modern practice and laboratory techniques.

Enrollment will be limited to 20 students per session, and persons desiring detailed information should write R. A. Diehm.

Besides Nadelman and Diehm, other members of the summer faculty will be J. A. Fanselow and Miss Carola Trittin.

Andreas von Koeppen will join the Western Michigan University faculty in February as a research professor in paper technology.

Earning his doctorate at the institute of Cellulose Chemistry, Darmstadt, Germany, Mr. von Koeppen worked in Finland and Australia before joining West Virginia Pulp and Paper Co., Covington, Va., in 1954. Two years later he moved to American Box Board Co., operations at Filer City, Mich.

Under terms of the research professorship agreement with American Box Board, Mr. von Koeppen's salary and incidental expenses will continue to be borne by American Box Board. He will teach one class in the department of paper technology at WMU, as well as continuing his research. Results of his work are to be published.

Initially the terms of the contract run until June, 1960, and will be renewed automatically unless cancelled six months in advance by either party.

A new program in industrial engineering will be offered at Western Michigan University in the fall of 1959, it was an-

nounced by President Paul V. Sangren, following approval by the state board of education.

"Because of the heavy concentration of industry in this area the establishment of such a program seems logical and wise," says Mr. Sangren, "and this particular type of engineering can be initiated at Western with our present staff and physical facilities."

A study of the possibilities of establishing industrial engineering has been underway for some time, being a normal progression from the technical programs which had their beginning on the campus in 1937. Through various studies, and with the concerted help of the advisory committee for industrial technology, it was found that with the addition of three courses in the area of applied mechanics a curriculum could be organized comparable to those found in the best engineering schools of the country.

Olin Mathieson

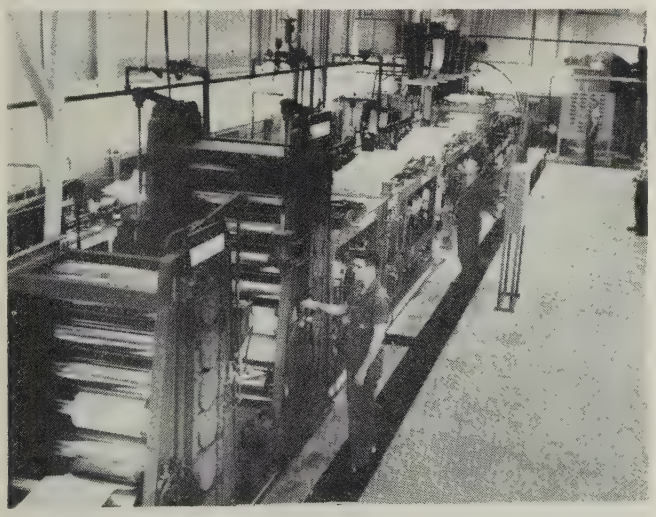
Olin Mathieson Chemical Corp. has opened a new research center and plans an accelerated program of research and product development at its forest products operations, it was announced by M. H. Collet, vice-president and general manager for forest products.

The new facility, called the "Frostkraft Research Center," is located at headquarters for forest products in West Monroe, La. More intensive research towards utilization of local hardwoods as a raw material would be one of the major objectives of the 1959 program, Mr. Collet declared.

The forest products operations are part of the Packaging Division of Olin Mathieson. Mr. Collet said that the increasing emphasis on research was part of a program to enable Olin Mathieson to supply its customers with a complete packaging service.

The Frostkraft Research Center is evidence of the corporation's determination to expand its position in the packaging field through the development of new products and the improvement of old ones according to Mr. Collet. He added that future growth of any major manufacturing operation today depends to a great extent on its emphasis on product research and development.

The forest products operations cover the production and sales of kraft paper products, pine lumber, hardwood flooring, and treated lumber.



This miniature paper machine plays an important part in the research efforts of the forest products operations of the Packaging Division of Olin Mathieson Chemical Corp. Located in the new research center at Monroe, La., headquarters for forest products operations, it is 70 ft. long, produces a sheet 24 in. wide, and can operate at speeds to produce 330 ft. of paper a minute. The machine is capable of duplicating all the functions of a giant papermaking machine

The center is under the direction of David C. Lea, research and development manager. Assisting him at the facility are Paul Gilmont, in charge of pulp and paper; Lawrence Shipman, head of packaging; Russell Jagoditsh, supervisor of coating operations; and Craig Campbell, responsible for lumber research.

The 12,000 sq. ft. building houses a pilot plant for paper manufacturing operations, laboratories, testing facilities, a technical library and offices.

Included in the pilot plant are an experimental papermaking machine designed by the Frostkraft research staff, pulping and bleaching equipment, and an experimental coater. The package laboratories contain an inclined impact tester, vibration tester, drop tester, and other testing equipment to simulate field conditions in testing packages. There are two controlled weather rooms to provide evaluation of material under varied weather conditions.

Roots-Connersville

R. R. Newquist, president of Roots-Connerville Blower Division of Dresser Industries, Inc., has announced the appointment of Glenn H. Crocker as general sales manager effective immediately. Mr. Crocker will have responsibility for the sales of Roots-Connersville equipment throughout the United States and Canada.

Pusey & Jones

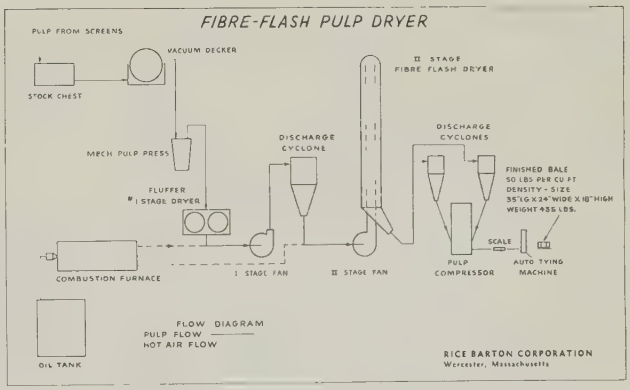
A new, easy-to-use calculator designed for fast paper mill calculations without using conversion factors, is available free from The Pusey and Jones Corp., Wilmington 99, Del.

With this paper production and drier calculator, production in pounds per hour and tons per day for 12 different ream counts, and drier requirements of steam pressure versus the number of driers for eight types of paper and five different drier sizes may be calculated.

Rice Barton

Rice Barton Corp. of Worcester, Mass. has concluded an agreement with D. & S. Engineering, Ltd., of Vancouver, B. C., whereby Rice Barton will design and build "Fibre-Flash" pulp drying systems. Employing the flash drying principle which originated in Switzerland, the first industrial plant of this new system for drying and baling pulp was developed in Canada during 1956 and 1957. The results were excellent and its operation on day-in and day-out production has proved successful.

The "Fibre-Flash" drying process for use with all types of pulp consists of dewatering the pulp, fiberizing the concentrated pulp material thoroughly to insure uniform drying, evaporation of the fiber-bound water to the required degree of dryness and baling or bulking the material into convenient form for storage or shipment.



Fibre-Flash pulp drying system

The drying medium, either combustion gases or hot air, carries the material to be dried through separate stages of the fiber-suspension-type flash drier. The relatively high intake temperature flashes-off the surface water and the drying tower provides the necessary time element to permit a complete heat exchange to extract the remaining moisture in the fibers. Drying occurs at high evaporation velocity which maintains a low fiber temperature.

Besides the main advantage of reduced freight costs in shipping market pulp dry, the "Fibre-Flash" method of drying and baling pulp offers the additional benefits of minimum capital investment and operating cost, peak thermal efficiency, reduced labor costs, simplicity of equipment with moving parts at a minimum, elimination of over-heating or case-hardening effect, and ease of repulping.

Pfaudler

Announcement of the latest in a continuing series of seminars on corrosion resisting process equipment has been made by The Pfaudler Co. a division of Pfaudler Permutit Inc., Rochester, N. Y. The seminar, which in the past has been widely attended by executives, engineers, and technicians in the processing industries, will be held in Rochester, N. Y., in May 1959.

The corrosion seminars are presented as an industry service. Both Pfaudler experts and authorities from other companies lecture on such subjects as: technology of glassed steel; corrosion resistance of glassed steel; design of glass steel equipment; heat transfer; heat exchangers; columns; selection of corrosion resistant materials; fabrication and welding of alloy equipment; repair and maintenance; tantalum, titanium, and zirconium; and other appropriate subjects. Ample opportunity is afforded to discuss common problems of corrosion in the process industries. Further information may be obtained by writing The Pfaudler Co., 1082 West Ave., Rochester 3, N. Y.

J. C. Brown, Jr., Improved Machinery Inc.

Impco

Improved Machinery Inc., Nashua, N. H. announces the appointment of J. Cameron Brown, Jr. as sales representative for Connecticut, Rhode Island, Central and Western Massachusetts, Southern New York, Eastern Pennsylvania, New Jersey, and Delaware.

Mt. Hope

In the series of technical bulletins issued by the Mount Hope Machinery Co., designed for the information of paper and production men, one, on the vital subject of better slitting and cutting operations, has been in special demand. It has pointed out a new function of Mount Hope rolls to many mill men, who have been limiting their application to one or two jobs in the production setup.

Now, more and more papermakers are using the rolls to insure open slitter cuts, prevent interleaving, and otherwise aid more efficient, less wasteful slitting and cutting. Other subjects covered in the technical bulletins which have been sent to most Mount Hope Roll users, and many non-users, include bow setting, drier operations, wrap and bow, spreading and size press operations. Copies of the new slitting-cutting bulletins may be obtained by writing Mount Hope Machinery Co., 15 Fifth St., Tauton, Mass.

Corn Products

Corn Products Sales Co., 17 Battery Place, New York 4, N. Y. is offering a new 20-page booklet entitled "ZEIN—A Versatile Protein for Industry" which describes the characteristics and uses of Argo Brand Zein G200.

Rust

William M. Crawmer has joined the Rust Engineering Co. as a staff consultant, engineering department, and will specialize in the design and construction of pulp and paper mills. Previously, he was pulp mill superintendent for Mead Corp. at their Kingsport, Tenn. plant. He had been with Mead for 10 years.

Koppers

Thurman F. Naylor has been appointed sales manager of the Metal Products Division of Koppers Co., Inc., Baltimore, Md., it was announced January 14 by Harry P. Neher, Jr., manager of the division's marketing department. In his new position, Mr. Naylor, former assistant sales manager, will have direct responsibility for district sales operations, development and administration of training programs for sales personnel, agents and distributors and the direction of contract sales.

Lamson

Lamson Corp., Syracuse, N. Y. announces the release of a new roller gravity handbook. It is a reference book for the engineer who uses conveyors to solve unit load handling problems.

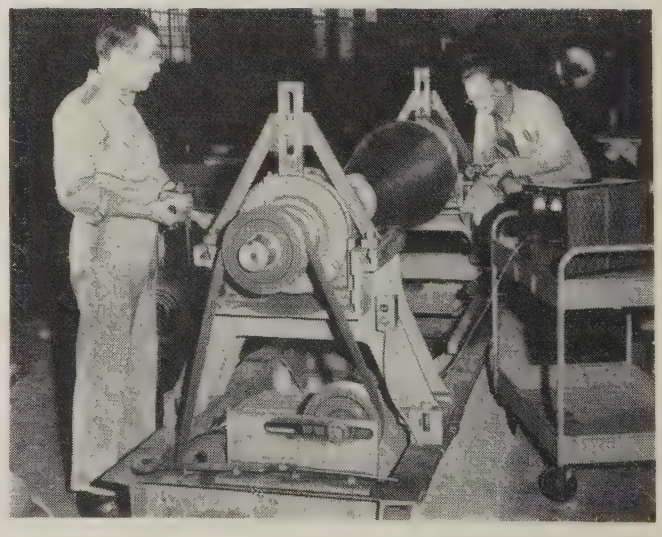
There are many descriptive illustrations and photos explaining the application of gravity conveyors and the more common accessories. Easy to read charts and graphs are included to assist the engineer to match a conveyor to the loads. "Roller Gravity By Lamson" has a new flavor in that it points out conditions to be avoided.

Bolton–Emerson

Dynamically balanced Emerson jordan plugs now drastically reduce jordan vibration, lower maintenance costs, increase tackle and bearing life, and improve stock quality, announced the Emerson Manufacturing Co., Division of John W. Bolton & Sons, Inc.

Dynamic balancing measures the vibration caused by centrifugal force and locates any points of unbalance in the plug as it is rotated at the exact speed it is to be mill-operated. Unbalance is then corrected.

An electronic analyzer is used to accomplish dynamic balancing. It consists of a vibration pick up probe, meters that register the amplitude and frequency of vibration and a



Balancing an Emerson jordan plug

stroboscope, by which points of unbalance are located on the body of a revolving plug.

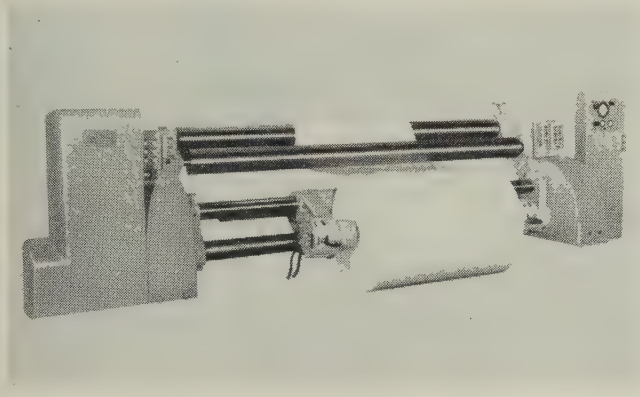
Emerson plug dynamic balancing replaces obsolete static balancing. Provided as a quality control measure on all plugs, dynamic balancing is standard practice at Emerson, even on the largest sizes ranging over 5000 lb., at no extra charge.

"With extremely close tolerances between tackles measured in microns," according to W. L. Bolton, Emerson plant manager, "coupled with tremendous thrust loadings and high tonnages at 300 to 600 r.p.m., dynamic balancing is essential to the best operating performance. Life of the equipment is longer, fillings life is lengthened and more accurate stock treatment results."

Plugs jacketed with Emerson stainless steel are also dynamically balanced at no extra cost. For further information, write the Emerson Manufacturing Co., Division of John W. Bolton & Sons, Inc., Lawrence, Mass.

B–C

One of the widest shaftless mill roll stands to operate under constant tension at high speeds was recently delivered by the Black-Clawson Co., Dilts Division, Fulton, N. Y. for application on a high-speed printing press.

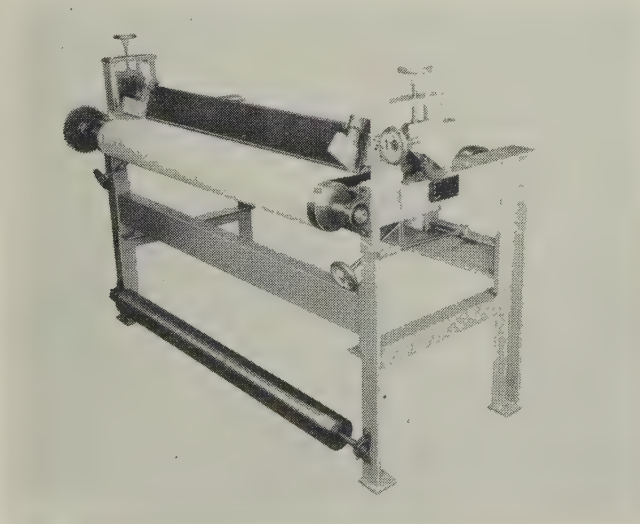


Model 54 shaftless roll stand

The Model 54(shown) will handle 40-in. diam. rolls to 110 in. width and lift the rolls from the floor or dolly. The stand has powered chucking and centering features.

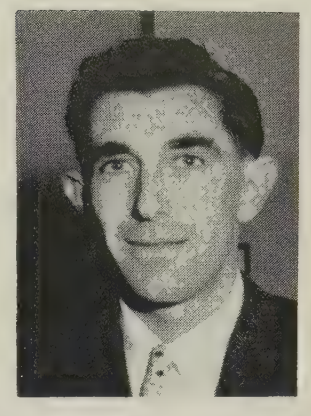
Automatically regulated, air-operated brakes with water cooling, provide constant tension control during unwinding.

The unit is used on many converting operations, such as slitter-winders, presses, laminators, and coaters.



Knife-over-blanket coater

James H. Austin, project engineer with the Paper Machine Division of the Black-Clawson Co., Watertown, N. Y. moved recently to Brazil where he is serving as chief engineer for Companhia Federal de Fundicao in Rio de Janeiro.



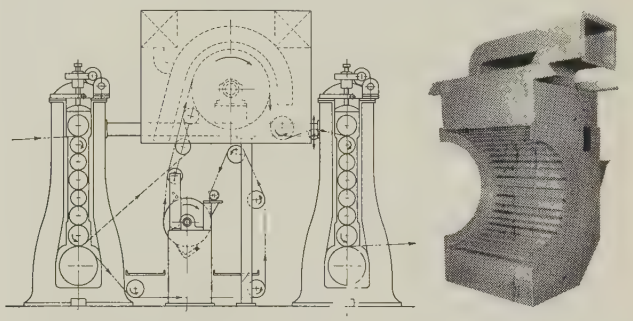
J. H. Austin, The Black-Clawson Co.

Companhia Federal de Fundicao is the licensed manufacturer of Black-Clawson pulp and paper mill equipment for the South American market. The firm employs 400 people and includes a foundry, machine ship, engineering department and sales organization.

A new knife-over-blanket coater for use in coating of paper and fabrics has been developed by the Black-Clawson Co., Dilts Division, Fulton, N. Y.

The coater pictured, offers versatility in blade adjustment and blade pressure. This additional unit rounds out the complete line of Dilts Division coating machinery for the Converting Industry.

A new and unique drier has been developed for the Black-Clawson Co., Dilts Division, Fulton, N. Y. for use with its "Flexiblade" and other type coaters by George R. Marsh, drier designer and Black-Clawson staff consultant.



Black-Clawson high velocity 3-D drier

Termed the "3-D" drier, which stands for high velocity, high temperature, and high volume, the new unit features an extremely efficient method of introducing and removing hot air evenly across the web. A laboratory size 3-D drier has been installed cooperatively in the laboratory of a prominent paper manufacturer for full evaluation at high speeds. Several production units are being manufactured. The 3-D drier is furnished for paper machine application for either steam or gas heating.

Freeport Sulphur

Consumption of sulphur toward the end of 1958 registered an increase over earlier months but the gain was insufficient to bring the annual rate to the level achieved in 1957.

In an annual review Charles A. Wight, president of Freeport Sulphur Co., attributed the lessened use of sulphur to the decline in business activity. Since sulphur is one of industry's most widely used chemical raw materials, its demand follows very closely the trends of business activity in general.

Preliminary data indicated that total domestic consumption of sulphur was off fractionally from 1957, reflecting the lower output of such major consuming industries as paper, steel, petroleum refining, rubber, and textiles. However, the relatively good year experienced by the fertilizer industry and segments of the chemicals industry, two of the largest consumers of sulphur, helped to bolster the consumption figure.

Sulphur production was also down, Mr. Wight said. Total output from all sources in the United States amounted to an estimated 6,200,000 long tons, compared with 7,000,000 tons in 1957. The drop in production was the result not only of lower consumption but also of increased imports and, more significantly, a cutback in stockpiling.

Of the total production, three quarters was brimstone mined by the Frasch hot-water process from salt dome deposits located along the coast of the Gulf in Louisiana and Texas. Indicated Frasch production was approximately 4,650,000 tons, compared with 5,490,000 tons in 1957. Of the balance of the output, 630,000 tons represented elemental sulphur contained in pyrites; and 520,000 tons sulphur in various forms from other sources.

Twelve Frasch-process mines were in operation in the United States in 1958, including a new mine opened in May by Texas Gulf Sulphur Co. at Fannett, Tex. Texas Gulf remained the largest producer, followed by Freeport Sulphur Co., Jefferson Lake Sulphur Co., and Duval Sulphur and Potash Co.

Both imports and exports of sulphur were up in 1958. Imports were at a record of approximately 760,000 tons, compared with 669,000 tons in 1957. The bulk—an estimated 600,000 tons—was Frasch sulphur produced from mines in Mexico.

Shipments abroad, all of which were made by the Frasch producers, were estimated at 1,575,000 tons, slightly higher than in 1957 and only 75,000 tons less than the record shipped in 1956.

To meet more effectively the increased competition abroad from foreign sources of sulphur, the four U. S. Frasch producers during the year formed the Sulphur Export Corp. to sell their sulphur outside the North American continent. The jointly owned company was created under the terms of the Webb-Pomerene Act, which permits companies within an industry to form a single organization to transact their business abroad.

The quoted price of sulphur in the United States has remained unchanged since the reduction of $3 a ton effected late in 1957. Prices during 1958 were quoted at $25 a long ton f.o.b. port and $23.50 f.o.b. mine.

Two new U. S. salt dome deposits were under development, both projects of Freeport Sulphur. The largest is Grand Isle, a discovery of major magnitude located off the Louisiana coast in 50 feet of water seven miles from the nearest land. The second, known as Lake Pelto, is situated some miles away in the shallow, partially protected water along the coast. At Grand Isle, a steel structure measuring nearly a mile in length was nearing completion at year's end, and production is expected in 1960.

National Starch

Kobond, the first cold water swelling carrier starch designed specifically for use in the corrugating industry, is now available in commercial quantities.

According to J. F. Fitzgerald, vice-president of National Starch Products Inc., New York, developers of the material, Kobond has been in field test for approximately nine months in limited quantities. Response during that time has been so great, he reported, that National is now in full production and can offer the new material in standard commercial quantities.

Kobond is said to represent an innovation in carrier starch formulation, since it is pre-cooked by National under carefully controlled conditions. In commercial use, no additional cooking is required. Kobond is simply added to cold water and mixed. The entire batch, carrier and raw starch, is prepared in the secondary mixer thereby changing a conventional two-step process to a single step operation—a 50% cut in plant preparation time. In addition, Kobond is completely compatible with any raw starch used in corrugating formulations.

OBITUARIES

John Jenkins Priest

John J. Priest, chief chemist of the Halifax Paper Co., Roanoke Rapids, N. C., died on Dec. 11, 1958, of a heart attack.

Mr. Priest was born in Lee, N. H., on April 6, 1904, and graduated as a chemical engineer from the University of New Hampshire in 1926.

Following graduation Mr. Priest became a research chemist for the Brown Co. at Berlin, N. H., and La Tuque, P. Q. In 1930 he became chief chemist of the Albermarle Paper Co., Richmond, Va., where he remained until 1944. During the years 1944–46 he was research chemist for the Virginia Carolina Chemical Corp. doing work on phosphates. Late in 1946 he returned to Albermarle and early in 1947 was sent to Albermarle's Halifax Paper Co. Division as chief chemist.

He was a member of The Technical Association of the Pulp and Paper Industry and was active in the work of its Water Committee.

Mr Priest is survived by his wife, the former Irene McGeorge, and one sister, Mrs. Walter J. Foster, Framingham, N. H.

Clarence LeRoy Durkee

Clarence L. Durkee, consultant for Bauer Bros. Co., died in his sleep of a cerebral hemorrhage in Springfield, Ohio, on Jan. 7, 1959.

Mr. Durkee was born in Arbor Vitae, Wis., on Dec. 18, 1900. Following high school graduation he joined the D. J. Murray Mfg. Co. in Wausau, Wis., as a pattern maker. He eventually became vice-president and general sales manager of the company. During the past few years he has been a free-lance consultant engaged in a number of private ventures relating to the development of new machinery for paper mills.

He was buried in Wausau, Wis., and is survived by his wife.

Robert J. Becker

Robert J. Becker, chemical engineer for the Riegel Paper Corp., was killed in an airplane crash in New York City on Feb. 3, 1959.

Mr. Becker was born in New York, N. Y., on Feb. 20, 1926, and graduated from the New York State College of Forestry in 1950.

He joined the Riegel Paper Corp. organization at Milford, N. J., in 1950 and soon thereafter he served in the U. S. Army. He returned to Riegel in 1952.

Mr. Becker was a member of the Fourdrinier Committee of the Technical Association of the Pulp and Paper Industry.

TAPPI DIVISIONS AND COMMITTEES

Reports of Activities

Plastics Laminates Committee

A meeting of Plastics Laminates Committee was held in New York at 10 a.m. on Jan. 19, 1959. In attendance were Messrs. Spencer, chairman (Knowlton Bros.) Seiler, vice-chairman (Behr-Manning), Morris, secretary (Allied Chemical), Yurick (Catalin Corp.), Doughty (Fitchburg Paper), Roeck (Durez Plastics), Laurie (Monsanto), Uong (Fitchburg Paper), Gilmore (Brown Co.), and Winchester (TAPPI).

Mr. Spencer described the meeting as a steering group to further the program of the larger committee since a general meeting would be unwieldy.

The first order of business was a report by the writer on the progress to date, on the analysis of the round-robin testing data. Due to the delay by one lab in sending in their data, we were unable to work on the project during November and December and are therefore at least two months behind. The whole analysis of alpha papers for initial and 99% penetration and of kraft papers for initial penetration has been completed. The kraft, 99%, has an error in it which we have not found to date and must find before proceeding. When the general analysis is completed the analysis of individual labs and fluids will then be carried through. It was reported that we felt that this could be pushed along further for the February meeting and that some second order instructions are significant in the general analysis but these must be sorted out for true significance and evaluated separately. The committee hoped that the project could be ready for a paper by the writer at the September meeting in Chicago and I advised that I hoped to have the work fairly well done and reported by early summer for circulation to the committee. It was agreed that the names of the participating labs should remain confidential since it will probably come out eventually that part of the significant variation among labs is due to poor technique and testing. Mr. Uong of Fitchburg suggested the use of the penescope or other size tester as a possible substitute for the Williams penetrometer. This was in line with a general discussion regarding end point. Difficulty in seeing both end points on alpha papers was encountered by some labs and the writer offered the thought of an alternative to visual evaluation such as an electrically timed end point. The data analysis to date indicate somewhat larger variation in average end point among labs for initial than final penetration and may be traceable to this problem. The precision is better for initial than final but is probably a factor of time. All appeared to be pleased wih progress to date since this project is moving along quite rapidly. Mr. Winchester asked for formal submission of the project to TAPPI for assignment of a project number. The number is 503 and will be used for future reference to the project. The subcommittee was formalized and the group voted that the writer be placed in charge of the subcommittee. I also added the names of Messrs. Seiler, Boehme (Panelyte), Morris, and Doughty to comprise the subcommittee since all had contributed time either fluids or papers to the effort.

The second item on the agenda, that of a test for total penetration of resin solids, was discussed generally. It was agreed that a Kjeldahl method was suitable for melamine or urea resins but that phenolic resins, partly or totally cured presented much more difficulty. Mr. Laurie mentioned a new ASTM ultraviolet method for melamine analysis and was to secure the procedure. It was felt that an extraction method for phenolics was not suitable because of the possible interaction with cellulose. Acetone is suitable but subject to interference at high temperature and humidity. Mr. Roeck was to coordinate various suggestions and report in February and Mr. Spencer asked that everyone give some thought to a possible method prior to appointment of a subcommittee to attack the problem.

Item 3, distribution of saturant in the sheet, was discussed next and Mr. Seiler reported on some investigations that he had carried out. Apparently melamine stains well while phenolics do not and Sudan 4 stain has been used with some success. Mr. Spencer had tried Diamine Fast Blue FFB and found it no good. Some work has apparently been done at I.P.C. and by various groups and the individuals were to check with their research departments for further details and report in February. Mr. Seiler is to coordinate this effort.

Item 4, apparent interference with saturation, was suggested by Mr. Spencer and he reported on two apparently identical rolls, a front and back, which saturated differently when run by a customer as a trial. One roll was used and worked well. The other shipped later did not. Two different resin batchs were used and examination of the sheets under the microscope showed unsaturated white areas. The paper was a waterleaf grade with nothing but fiber and the problem apparently unexplainable. He felt that it might be due to some problem at the interface of resin and fiber. The general consensus of the group was that this was still one of distribution and should be tabled until something tangible could be reported on item no. 3.

Mr. Morris reported on progress with the questionnaire to potential members of the committee as outlined by the officers at the October meeting an hoped to have some response by the February meeting. Mr. Winchester also assigned project numbers to those discussed as items 2 and 3.

D. M. Gilmore

Drying Committee

The Drying Committee met Jan. 7, 1959, at 11:00 a.m. in the TAPPI Headquarters Conference Room, New York, N. Y.

Members in attendance were:

S. G. Holt, Consolidated Water Power & Paper Co., chairman
G. E. Jackson, Bowaters Southern Paper Corp., vice-chairman
K. K. Khandelwal, Rice Barton Corp., secretary
L. Blomgren, American SF Products, Inc.
G. H. Cash, Industrial Air Co.
F. L. Cessna, Sorg Paper Co.
H. P. Fishwick, Mason-Neilan Division of Worthington Corp.
A. Hallencreutz, American SF Products, Inc.
F. G. Perry, Arthur D. Little, Inc.
H. W. Stevens, S. D. Warren Co.
R. C. Swaney, S. Morgan Smith Co. & Beloit Iron Works
L. R. Vianey, The Eaton-Dikeman Co.
R. E. White, Villanova University

Guests in attendance were:

W. K. Metcalfe, J. O. Ross Engineering (for L. G. Janett)
A. J. Winchester, TAPPI (for H. O. Teeple)

The meeting was called to order at 11:00 a.m. by S.G. Holt, chairman. The minutes of the previous meeting were read and approved.

Papers for the 1959 Engineering Conference

A. "Nondestructive Testing," S. A. Wenk, University of California. E. G. Drew was to get in touch with Mr. Wenk. The committee was informed that Mr. Wenk will not be able to attend the Pittsburgh meeting and two other substitute speakers were suggested for the same subject. F. G. Perry and K. K. Khandelwal are to contact the potential speaker in Massachusetts.

B. "Study of Thermal Properties of Wet Paper Sheets," by J. F. Bakken and W. L. Ingmanson, The Institute of Paper Chemistry. S. G. Holt reported that this paper is expected to be ready for presentation at the 1959 Pittsburgh meeting.

C. "Wet Pressing," by R. E. White, Villanova University. White reported that this paper will be ready for presentation at the Pittsburgh meeting.. This paper will present data on moisture contents of papers and felts at different temperatures and pressures with static pressing.

D. "Flakt Pulp Drier," G. E. Jackson, Bowaters Southern Paper Corp. Mr. Jackson reported that he has accumulated interesting data on this drier during his recent trip to Europe. He expected their machine to be in operation by August. The paper will cover some of the operating experience with this drying system.

E. "Report on Project No. 505—Drying Rates of High Pressure Driers," Subcommittee Chairman F. G. Perry reported that questionnaires have not been sent out yet and therefore no data are available as yet. L. G. Janett is to be contacted for a report on distribution of questionnaires.

L. G. Janett was represented by W. K. Metcalfe at the meeting. It was resolved that the TAPPI office could do the mailing job to help matters and Janett is to send the questionnaires to H. O. Teeple for reproduction and mailing.

Papers Proposed for Future Meetings

L. Blomgren reported that the Forest Products Laboratory of the Royal Institute of Technology in Sweden had done much research with the hot press. A report on this research was published in Sweden and permission has been obtained to translate this paper.

It was resolved that S. G. Holt address a communication to B. Steenberg, at the Swedish Forest Products Laboratory requesting a presentation of a paper to the TAPPI meeting by someone from his staff.

It was suggested that committee members start searching for papers on interest for the 1960 meeting of the Engineering Division.

An up-to-date list of committee members has been compiled and mailed out to the committee members.

Data Sheets Subcommittee

H. W. Stevens reported that the Data Sheets Committee of the Engineering Division had not held any meeting yet. A. J. Winchester reported that the master index for the Drying Committee was in good order and no further work is required at this stage.

Drying Rates Subcommittee

F. G. Perry reported that he has been in touch with the Canadian Pulp & Paper Association and has received copies of their data sheets. He will circulate these data sheets to interested subcommittee members and make a recommendation to the committee.

R. C. Swancy was appointed by S. G. Holt to be the program chairman for the Pittsburgh meeting.

Status of Active Committee Projects

Project No. 757. Preparation of a data sheet or a paper on infrared gas drying of pulp. In the absence of the subcommittee chairman, J. J. Kilian, A. Hallencreutz stated that nothing new was to be reported on this project. R. C. Swaney's resignation from this subcommittee was accepted, in order that he might be assigned to project no. 795.

Project No. 756. Drying fundamentals. This project was established to study the use of high-frequency current in paper drying. L. R. Vianey, member of the subcommittee, reported that he had procured names of manufacturers of high frequency source and was proceeding to obtain more information.

Project No. 759. This project was established to study the use of gas turbines as sources of shaft power and high level thermal energy for drying purposes. It is hoped that this will develop into a comprehensive paper on this subject. The subcommittee is to be headed by G. E. Jackson and assisted by R. C. Swaney and F. L. Cessna.

Project No. 760. The purpose of this project is to find someone who can give an engineering and economic analysis of high velocity air jet driers for paper drying. A subcommittee was established with the following membership: C. H. Cash, chairman, L. Blomgren, W. K. Metcalfe, W. F. Overly. Their aim should be to find a speaker on this subject for the 1960 meeting of the Engineering Division.

Committee Membership

A. J. Cirrito's resignation as secretary of the Drying Committee was accepted. K. K. Khandelwal was nominated and elected as the new secretary.

Jean P. Gshwind, vice-president of research at J. O. Ross Engineering, will be invited to join the Drying Committee.

The meeting was adjourned at 3:30 p.m.

K. K. KHANDELWAL, *Secretary*

TAPPI DRYING COMMITTEE MEMBERS

Sherwood G. Holt, Chairman, Consolidated Water Power & Paper Co., Wisconsin Rapids, Wis.
George E. Jackson, Vice-Chairman, Bowaters Southern Paper Corp., Catawba, S. C.
Krishna K. Khandelwal, Secretary, Rice Barton Corp., 65 Tainter St., Worcester 1, Mass.
Lars Blomgren, American SF Products, Inc., 420 Lexington Ave., New York 17, N. Y.
George H. Cash, 5 Stoneybrook Rd., Darien, Conn.
Frank L. Cessna, Jr., Sorg Paper Co., Middletown, Ohio
A. J. Cirrito, Rice Barton Corp., 65 Tainter St., Worcester 1, Mass.
Robert M. Cook, Ross Midwest Fulton Corp., Dayton, Ohio
Everett G. Drew, Drew Engineering Co., 809 N. E. Lombard St., Portland 11, Ore.
Horace P. Fishwick, Mason-Neilan Regulator Co., Norwood, Mass.
W. Andrew Green, Jr., Manchester Board & Paper Co., Richmond, Va.
Arne Hallencreutz, American SF Products, Inc., 420 Lexington Ave., New York 17, N. Y.
S. T. Han, The Institute of Paper Chemistry, Appleton, Wis.
Leslie G. Janett, J. O. Ross Engineering Corp., 201 N. Wells St., Chicago, Ill.
Joseph J. Kilian, West Virginia Pulp & Paper Co., Research Center, Covington, Va.
George R. Lydick, The Beckett Paper Co., Hamilton, Ohio
John M. Mallory, Union Bag-Camp Paper Corp., Savannah, Ga.
William F. Overly, Overly's, Inc., 214 Jackson St., Neenah, Wis.
Richard A. Paramore, Central Fibre Products Co., P. O. Box 1033, Hutchinson, Kan.
Fred G. Perry, Arthur D. Little, Inc., 30 Memorial Drive, Cambridge 42, Mass.
Howard W. Stevens, S. D. Warren Co., Cumberland Mills, Me.
R. Casper Swaney, P. O. Box 215, Carlisle, Pa.

Lucien R. Vianey, The Eaton-Dikeman Co., Mt. Holly Springs, Pa.
Robert E. White, Dept. of Chemical Engineering, Villanova University, Villanova, Pa.
Stanley C. Williams, Dominion Engineering Works Ltd., P. O. Box 220, Montreal, P.Q., Canada
H. O. Teeple, TAPPI Representative, 155 East 44th St., New York 17, N. Y.

Hydraulics Committee; K. J. Mackenzie, Chairman, Eastman Kodak Co., Rochester, N. Y.

Fluid Mechanics Committee: N. Shoumatoff, Chairman, West Virginia Pulp and Paper Co., New York, N. Y.; C. A. Lee, Vice-Chairman, Kimberly Clark Corp., Neenah, Wis.; J. A. Smith, Secretary, Clark and Vicario Corp., N. Tarrytown, N. Y.

Alkaline Pulping Committee Meeting. Standing l. to r.: M. Owen, D. Wetherhorn, D. C. Gillespie, P. B. Borlew, A. W. Pesch, H. O. Teeple. Seated l. to r.: P. H. West., C. Ratcliff, D. O. Adams, M. B. Pineo, K. D. Running, J. McK. Limerick

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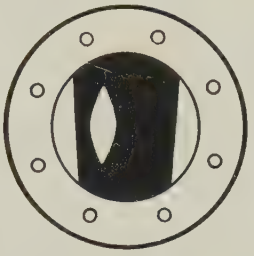

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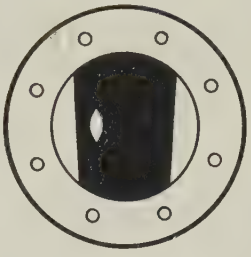

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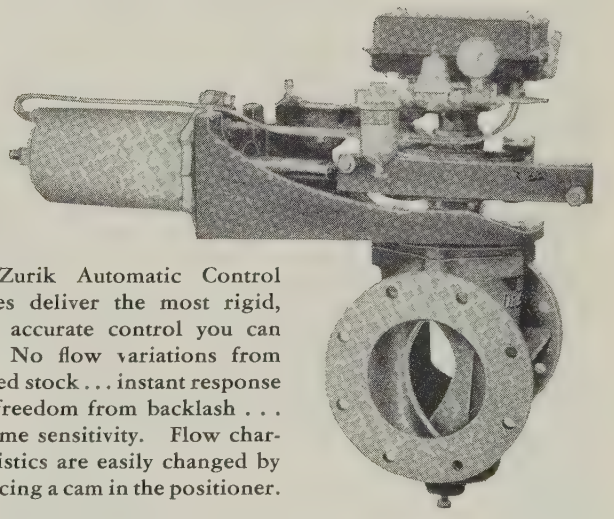

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LOCAL SECTION ACTIVITIES

Reports of Meetings, Personnel, and Events

Golden Gate

A meeting of the Golden Gate District of the Pacific Section of TAPPI was held on Tuesday evening, January 27, at the Hotel Claremont, Berkeley, Calif., with 92 present.

Three very fine speakers were featured: George Frank of Hamm's Brewing Corp. who spoke on "Problems with Board and Paper in High Speed Packaging"; George Swindsman of General Mills who spoke on "Consumers Comments in Connection with Board and Paper Packaging Problems"; Wm. Watt of C&H Sugar whose subject was "Technical Problems in the Use of Paper Products."

The next meeting has been changed from Tuesday, March 24, to Tuesday, March 31. We will have a trip through C&H's plant at Crockett, Calif. and have dinner as guests of C&H.

H. A. Harvey, *Secretary-Treasurer*

St. Louis District

The St. Louis District of TAPPI held its last meeting on January 15 at Le Chateau Restaurant.

The speaker of the evening was Paul Gronendyke, of National Starch Products, Inc., of Chicago, Ill. Mr. Gronendyke gave a very interesting talk covering packaging adhesives of both dextrine and resin construction. This was followed by a very interesting question-and-answer period.

J. H. Addison, *Publicity Chairman*

Paul Gronendyke, National Starch Products, Chicago, Ill., and William Rice, Central States Paper Co., St. Louis, Mo.

Chicago

The February meeting of the Chicago section of TAPPI was held Tuesday evening, February 3. Despite the prevailing bad weather, the attendance was excellent which, perhaps, attests to the broad general interest in the subject material presented.

The topic of discussion was "the new aspects of adhesives."

Dick Smith, Jim Lyon, Ray Stone, Mel Snover, John Coffey, Henry Klauke, and Paul Gronendyke at the February meeting of the Chicago section

John Coffey, field technical service representative of National Adhesives Co. was the first speaker and presented a paper titled "Vinyl Emulsions, Key to Packaging Efficiency." His discourse was supplemented with slides.

Dick Smith, Ray Stone, and John Coffey, (all speakers) and Paul Gronendyke

Raymond Stone, director of research, Morningstar-Paisley, Inc., spoke on "Why Latex Is a Suitable Raw Material for Adhesives."

The final speaker was Richard Smith, vice-president for research and development, H. B. Fuller Co. He spoke of "The Future of Hot Melt Adhesives in Paper Converting."

Each speaker's presentation was excellent, and a lively question-and-answer period followed.

C. M. Helm

Gulf Coast

The Gulf Coast Section of TAPPI met at the Stafford Hotel in Tuscaloosa, Ala., on Jan. 16, 1959. Chairman J. E. Doyle presided at the meeting.

Greetings and welcome to Tuscaloosa were extended by Malcolm May, manufacturing manager, Gulf States Paper Corp. Charles LaDow, plant manager of Huyck Felt Co. at Aliceville, Ala., invited the membership to visit the Aliceville plant Saturday morning, Jan. 17, 1959.

Following the social hour and dinner, the business session was held. Chairman Doyle announced that the executive committee had selected a nominating committee to recommend officer candidates for the 1959–60 year. The nominating committee is as follows:

W. P. Shannon, St. Joe Paper Co.
Vincent Waters, Southern Pulp and Paper Manufacturer
L. E. Thompson, Hercules Powder Co.

After the business session, Local Arrangements Chairman Arden Walker presented the speakers and their subjects as follows:

"Chip Analysis and Classification of Purchased Chips," by Bernard Cox, Gulf States Paper Corp.
"Experiments Using Elemental Sulphur and Total Chemical on Commercial Size Cooks," by H. M. Owen, Gulf States Paper Corp.
"Principles of Felt Manufacturing," by Wilhelm Moe, Huyck Felt Co.

Saturday morning, Jan. 17, 1959 was devoted to a tour of the Huyck Felt Co. at Aliceville, Ala. The luncheon after the tour.

A. L. Hargraves, *Recording Secretary*

Maine-New Hampshire

The following paper was presented at the meeting of the Maine-New Hampshire Section of Tappi held in Oreno, Me.

A Review of Pulp Stock Friction Studies

Richard E. Durst

The historical development of the fund of knowledge now available covering the properties and behavior of pulp stock suspensions in flow began with the publication of the Trimbey curves (*1*) a half century ago. The curves were based on tests made using riveted steel pipe. The data were found to be quite satisfactory for at that period in the industry positive displacement pumps were the standard, production was not on as large scale and power consumption for pumping pulps was not a matter of great concern.

Twenty-five years elapsed before any major work was published dealing with the friction of pulp stocks flowing in pipes. The centrifugal pump had replaced the positive displacement pump and mill men were increasingly aware of the friction problem involved in pulp stock transportation. Two significant investigations were made and published in the early thirties. Frank Forrest and G. A. H. Grierson (*2*) published their studies on pulp suspensions flowing in cast iron pipe using sulphite and groundwood stocks. The results are the well-known Allis-Chalmers pulp stock data sheets in wide use today. Bond (*3*) wrote on the use of centrifugal pumps, including reference to the work he and his co-workers had done pumping high density stocks. He proposed coefficients to correct the basic unbleached sulphite curve for bleached stock, beaten stocks, and groundwood pulp.

The results of other investigators followed those of Forrest and Grierson and of Bond in increasing number. Brautlecht and Sethi (*4*) published additional data on sulphite pulps, including power demands under varying conditions of the tests. This work was done in the Chemical Engineering laboratories here at the University of Maine.

The outstanding work of Walter Brecht and H. Heller (*5*) in Germany was published in 1935 but due to the conditions existing for a number of years was not readily available until a translation appeared in *Tappi* in 1950. This work was no doubt the most extensive of any pulp flow studies made and published up to that time. Dr. Brecht and his co-worker included data showing some of the effects of freeness change on pulp friction and also showed the temperature coefficient as it affected pulp stock pipe friction. The statement is made in the text of the publication that the data are factual only, no attempt being made to correlate the data nor to show any basis for extrapolation beyond the range of the conditions studied. The authors recognized the desirability of a basis for correlation of the variables in pulp suspension properties with the variables in pulp flow, yet realized the vast gaps in the knowledge that would have to be filled before such correlation was possible.

The first studies of pulp suspension behavior not involving flow in pipes appeared in 1938 and 1939. Moss and Bryant (*6*) made a photographic study of the motion of fibers and water in flowing fiber suspensions. Baldwin and Van den Akker (*7*) used a modified rotating viscometer to study the friction between solid surfaces and moving paper stock suspensions. This work resulted in the recognition of two types of friction existing in pulp suspension flow; the first the solid surface-moving stock friction, the second the stock to stock friction. These investigations were directed toward the general objective indicated as desirable by Brecht, i.e., a basis for correlating laboratory measurable properties of the suspension with the mass properties exhibited as friction in the pipe. Cooper (*8*) proposed using pipe friction with the Fanning friction plot to calculate apparent viscosity values for the pulp suspensions. His work did not receive the recognition it should, perhaps because the idea that a suspension has a varying shear stress-shear rate relationship was so novel. The science of rheology and the teachings of the early rheologists, Buckingham, Bingham, Green, and Mooney, to mention only a few, had not begun to be a part of the practicing knowledge of the engineers engaged in the design and operation of pipe lines carrying suspensions. Furthermore, it was reasoned that if the viscosity of the suspension did vary as was indicated by Cooper's calculations, how would it be possible to make reliable calculations of friction losses for pulp stocks. Nilson (*9*) suggested a partial answer to the peculiar shape of the friction loss curve which includes the idea of varying viscosity without defining it. He theorized that the presence of the fibers in the suspension served to reduce turbulence in the mass of material thus reducing the friction in certain intermediate velocity ranges. The fibers served to increase the friction in the lower velocities; while finally at the higher velocities turbulence develops and the curve approaches the water curve. Gray and Van den Akker (*10*) continued the work of Baldwin and Van den Akker developing their theory of the mechanism of flow of paper stock in pipes. The terms, plug flow, transition, and turbulent flow soon came into popular usage in connection with flowing fibrous suspensions.

Mason (*11*) made the first of his important contributions

Richard E. Durst, Professor of Chemical Engineering, University of Maine, Oreno, Me.

to the knowledge of pulp flow by reporting on the motion of fibers in flowing fluids. The forces acting on fibers in moving fluids were found to be definable and their influences made the motion of the fibers predictable. In further work Mason and co-workers (*12*) used radioactive tracers to measure fiber flow and the distribution of the fibers in the mass of the suspension. Thus the efforts of investigators had changed from the study of the behavior of the over-all mass of the suspension to the minute detailed behavior of individual fibers, from the macroscopic viewpoint to the microscopic viewpoint.

Victor Head (*13*) followed the teachings of Buckingham and Bingham in his study of suspension behavior and proposed a slope viscosity for most suspensions which exhibit a structure which requires an initial yield stress to induce shear in the suspension. From theoretical considerations he developed a shear criterion which enabled him to predict the behavior of diverse suspensions including tomato paste, cream corn, baby foods as well as paper pulp stock flowing in valves and rotameters.

Favis, Robertson, and Mason (*14*) applied new techniques in their study of pulp suspensions, and found that the optical heterogeneity of flowing pulp suspensions were a significant property of the suspension. Changes in optical transmission were found to conform to the flow curve. Thus the flow pattern was made subject to correlation with the friction of the suspension as it was observed in transparent tubes.

The large mass of data that had been added to the literature of pulp flow from 1932 to 1950 encouraged Palmgren and Hedstrom (*15*) to study the data using the known laws of hydrodynamics to determine if they could be made to apply to fibrous suspensions. The wide divergence in the data suggested to them that there must be some data that would be amenable to analysis. Their conclusions following an exhaustive study summarize the problems of pulp stock flow. They stated that either the data available to them were very inaccurate or the flow of pulp stock is very complex and not subject to the usual laws of hydrodynamics. In either case more experimental work and fundamental research into suspension flow is necessary.

The Hydraulics Committee of TAPPI undertook a research project to further the knowledge of pulp stock flow. The project was set up at the University of Maine in the Department of Chemical Engineering in 1951. An analysis (*16*) of the major bodies of data relative to pulp flow was made which showed that about 70% of all the data could be correlated to a friction factor by means of a pseudo-Reynolds number, which incorporated the factors pipe diameter, velocity stock density, and consistency with a spread of the correlation of about ±40%. Because of the simplicity of the correlation it has found rather wide application. However, the objective of the Hydraulics Committee was for a more accurate method of estimating pipe friction. A flow system was erected in the Chemical Engineering Laboratory at the University of Maine for the measurement of pipe friction on known pulp stocks. Concurrently studies were initiated to develop a laboratory device which would measure a property of the pulp stock which property could be used as a basis for correlation with the pipe friction. Viscometry studies were indicated as the most likely to yield data on the pulp stocks. A large scale rotating bob viscometer was built for measuring the shear stress-shear rate relationships of pulp stocks of several consistencies. A number of studies (*17, 18, 19*) have been published correlating pipe friction with the data obtained with the viscometer. Victor Head of Fischer-Porter collaborated in the work and proposed the simplified shear tester announced at the Engineering Conference of TAPPI in Portland, Ore., July, 1958. This instrument is available from the Fischer-Porter Co. and can be used by any one skilled in general laboratory work. A TAPPI data sheet is now in preparation which will incorporate the shear stress of pulp suspensions, the pulp fiber length, pipe diameter, and pipe roughness to provide a means of predicting pulp stock friction.

The research on pulp stock flow cannot cease here. The flow of model fibers was very ably investigated by Schieck (*20*). The influence of the *L-D*, length to diameter ratio of the fibers was shown by this study to be a dominant factor in the shape of the head loss curve. This work needs to be extended. The effects of the pulp variables have not been investigated in any exhaustive manner.

The effect of fittings in the pipe system has been studied and reported by only three investigators (*2, 21, 22*). The most recent work was done here at the University as part of the project of the Hydraulics Committee of TAPPI. Considerable emphasis in that work was placed on the measurement of the pressure drop in the straight pipe sections following the fittings. Briefly, it was observed that the pressure drop in the straight section following the fitting as much as 50 to 75% below the pressure drop in a straight section of equal length which was preceded and followed by straight section calming lengths. The complete results of the study will be published in *Tappi* in a future issue.

There are variables in the pulp suspension which are in need of study. The influence of entrained and adsorbed gases on the flow of the stock should be investigated. Separation of the gas from the stock can occur at points of rapid change of velocity or of pressure. The separated gas then will disturb the steady state flow of the stock.

Piping materials other than the widely accepted cast iron, steel and, more recently, stainless steel are coming into use for transporting pulp. Plastic pipe will no doubt find wide application in many areas. The influence of the piping material other than roughness should be determined. It is not too presumptuous to expect that static and electromagnetic effects may be of such importance that they should be included in the over-all evaluation of pulp stock friction. Dispersing agents and surface active agents will be investigated for their effect on pipe friction as a master's thesis study to be made during the next year. Many other very interesting and important topics for study can be listed, only the lack of workers and time preventing their immediate undertaking.

Obviously the works and workers covered in this review do not represent all the material that has been published relative to pulp suspension flow. Rather, the objective of the review has been to show the development of the knowledge that is now available to aid in the solution of the problems encountered in the transportation of pulp stock in slurry form, and to point out a few of the problems remaining to be investigated.

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Presented at the meeting of the Maine-New Hampshire Section of TAPPI held in Oreno, Me., Oct. 24–25, 1958.

LETTERS TO THE EDITOR

Scholarships

To the Editor, *Tappi:*

We read with considerable interest the article appearing in the April, 1958, issue of *Tappi* relating to scholarships. We had no knowledge that such a survey was being conducted and are happy to outline the Scholarship Program of The Weston Wabash Foundation.

The Foundation was created by The Western Paper and Manufacturing Co. and its wholly-owned subsidiary, Wabash Fibre Box Co.

The Weston Paper and Manufacturing Co. owns a paper mill in St. Marys, Ohio, and a mill in Terre Haute, Vigo County, Ind. Wabash owns a corrugating box plant in Terre Haute, Vigo County, Ind., and in Chicago, Ill.

Each year, the Trustees award a scholarship to a boy graduating from St. Marys Memorial High School and a second scholarship to a boy graduating from the school system in Vigo County, Ind. If the student selects a school supported by tax funds, his scholarship amounts to $500.00 per year and an additional $500.00 per year is paid either to The Ohio Foundation of Independent Colleges if the boy is graduated from St. Marys Memorial High School, or to the Associated Colleges of Indiana if the boy is graduated from the school system of Vigo County. Should either boy select a school not supported by tax funds, each boy receives $1000.00 per school year.

There is no restriction on what school the boy may attend. The selection of the recipient is made by a Scholarship Selection Committee, on which no Trustee or employee of the Foundation serves.

There is only one restriction by the Trustees, the scholarship will not be paid should the boy select medicine or dentistry as his profession.

Neither the company nor its subsidiary requires the recipients of the scholarships to work for the company, nor do they guarantee employment.

The scholarship is continued each semester, providing the boy has passing grades and is not refused admittance because of poor grades.

In addition to these scholarships, the Foundation pays $1000.00 per year to Indiana State Teachers College of Terre Haute, Ind. This fund is used by the school to provide scholarships to not less than two boys in the School of Business Administration. Our company or its subsidiary endeavors to provide employment for these boys, and does not guarantee employment.

E. W. Weston, *Treasurer*
Weston Wabash Foundation

TAPPI Fibrary

To the Editor, *Tappi:*

A brief report on the TAPPI Fibrary may be of interest to the membership.

During the calendar year 1958, requests were received by the custodian for 697 specimens. In a few cases it was necessary to make suitable substitutions or to refund money because certain samples have been exhausted since the most recent catalog was published in the 1958–59 TAPPI Yearbook (p. 94–107).

It is planned to publish another addendum to the fibrary before the next catalog is issued. I would appreciate receiving additional authentic pulps, such as jute, abaca, or manila fiber, oat straw, rye straw, from the members. The information to be listed in the catalog is needed with the samples. In addition to the species mentioned, other samples not presently listed would be welcome as it is our wish to make the fibrary of continual and increasing value to the industry microscopists.

If reprints of the catalog or further information is desired please write to the undersigned.

Irving H. Isenberg, *TAPPI Fibrarian*
The Institute of Paper Chemistry, Appleton, Wis.

No. 1 Brown Stock Washer Operation

To the Editor, *Tappi:*

According to my information, many kraft pulp mills are having considerable difficulty on the first brown washer stage. The main troubles are found to be as follows: low vacuum, high temperature, and low freeness, due to high soda content. The result from the three is well known to all operators in form of: sheet falling off; plugging of the vat; interruption of an even production rate, which in turn causes; (1) uneven washing, (2) uneven soda losses, (3) uneven filtrate Baumé, washer face wire tears, shifting, and/or loss of wire.

Number 1 washer vacuum will nearly always be found to be lower than on no. 2 and no. 3 washers. The reasons for this are: high temperature, filtrate containing high degree of solids, considerable higher consistency in no. 1 vat due to lower freeness, and the mushiness of the stock, which causes air to filtrate through it more evenly. My study indicated the following results. The sheet will fall off when: (1) too high a shower pressure is applied to the first showers, washing the stock back into the vat and thus plugging it; (2) the vacuum drops: (a) packing gland leaking. Due to the high temperature, the liquor will leave a slight film of soda on the inside of the packing and thus reduces its flexibility, therefore, air will enter. (The gland may be as tight as can be.) This in turn can be corrected by: (i) placing a water line or hose on the outside of the packing gland (not particularly recommended since the water will corrode the steel in the area and enter the gear case); (ii) installing grease gun adapters to the seal ring packing in order that the operator may periodically inject some heavy grease. (*b*) Steam flash back in the barometric leg. To consider this it is necessary to view the entire operation. Suppose there are three countercurrent flow vacuum washers, without vacuum pumps.

1. During digester blows stock at some 14% consistency and a temperature of about 320°F. (±20°F.) is discharged into the blow tank.

2. At high production rates and low blow tank levels, radiation may cause a temperature loss of about 40°F. (±20°F.).

3. The liquor temperature as injected to the blow tank cone is about 190°F. (±10°F.). The stock is diluted to 2 to

High machine speeds?
High temperature headbox stock?
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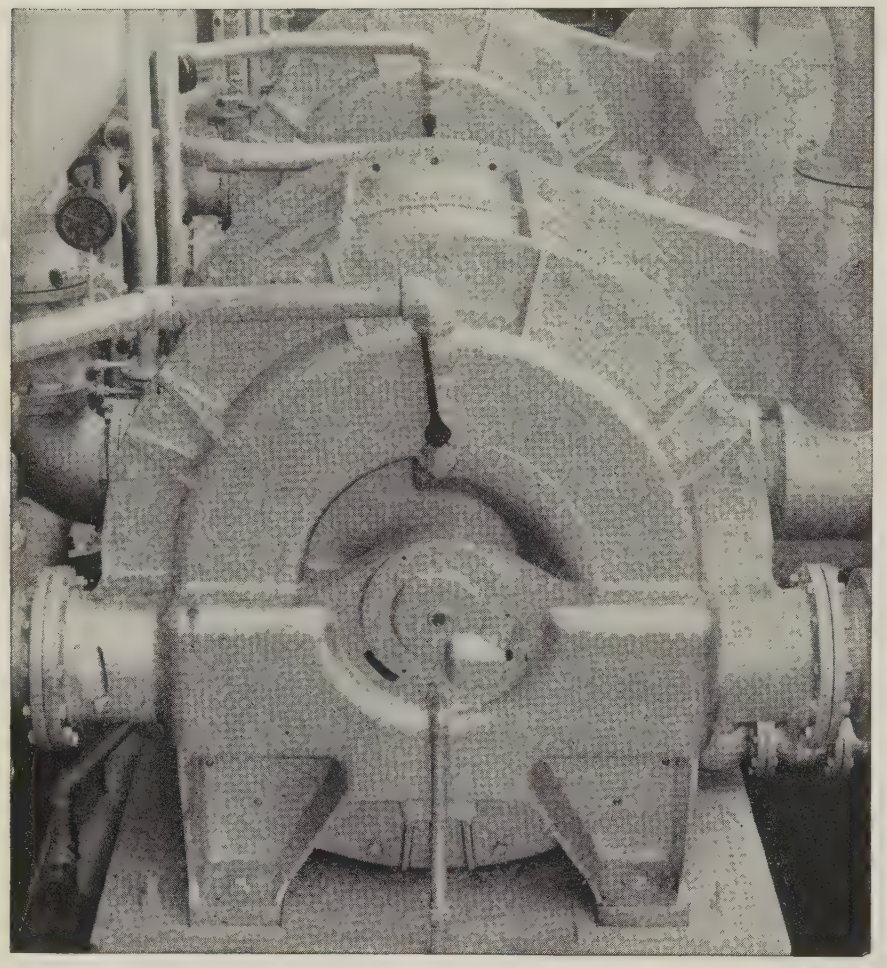

Air from the suction rolls on paper machines carries with it substantial quantities of moisture. This considerably reduces the effective air handling capacity of any vacuum pump except the Nash. In the Nash Vacuum Pump, because of the unique principle of operation, the bulk of this vapor is effectively condensed inside the pump. The total capacity of a Nash is therefore increased.

When you specify a Nash Pump it can be closely sized to the job. It is not necessary to select an over-sized unit, because the rated capacity of the Nash may be relied upon.

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perature is reduced to 210°F. (±10°F.).

4. On the preknotters, where the biggest single over-all radiation loss may be achieved through good ventilation, the temperature will be reduced to 195°F. (±10°F.)

5. Number 1 washer vat temperature is thus still above 190°F. causing it to reach the boiling point under vacuum in the barometric leg. Therefore, as a liquor drains off it causes a counter pressure which reduces the vacuum to the break even point. This is the main reason why no. 1 washer vacuum gage will always show lower readings than nos. 2 or 3. The trouble will start as soon as the counter pressure, formed by excess temperature, lowers the vacuum to about 4 in. This being insufficient for pickup, air enters, and that portion of the wet sheet on the drum will fall back into the vat.

To find a feasible solution it is again necessary to review the entire operation:

1. The best and most efficient wash may be obtained through the highest possible washing water or liquor temperature, therefore, 160 to 170°F. as water temperature to no. 3 washer showers is satisfactory.

2. By the time this water appears as filtrate on no. 2 washer showers it has lost some 10°F. by radiation, providing no one has placed a cold water hose into no. 3 vat or seal tank in order to knock down the temperature. (This certainly increases the efficiency!!!)

3. When the filtrate finally comes to no. 1 washer, it has a temperature of some 140 to 150°F. after another 10°F. radiation loss.

Conclusion: it is therefore not advisable to reduce the temperature on any of the washing stages, since the least soda loss possible is desired.

4. According to the inventor of the oxidization tower, it will not require a higher temperature than 160 to 170°F.

5. Evaporator feed temperatures are somewhere around 120°F. The heat loss in the oxidation tower is about 40°F., therefore, by assuring 160°F. to the tower the operation from there on will not be affected.

6. Number 1 seal tank (no. 1 washer filtrate tank) temperature of 190°F. (as mentioned previously) is at least about 20°F. too high.

Conclusion: By reducing the temperature in no. 1 seal tank by 20°F. the stock temperature to no. 1 washer would be well below the danger point of causing flashsteam in the barometric leg, and the over-all operation will not suffer.

The most common way of reducing temperature in a productive way

is by heat exchanger, therefore, it will be necessary to find an adequate cooling medium. This may be: (1) the water used on no. 3 washer showers, (2) water used in the bleach plant, and (3) water used as make-up in the recausticizing section. When deciding upon the flow of the liquor, it is obvious that the return line from the heat exchangers should discharge into the suction of the blow tank dilution pump. The heat exchanger feed pump in turn should be as close as possible to the seal overflow, in order to feed liquor at the highest temperature.

Conclusion: no. 1 brown stock washer operation can only be efficiently improved by reducing the stock temperature.

R. A. D. Bezzola
Crofton, B. C.

EMPLOYMENT SERVICE

Positions Wanted

E464-59 Chemist (Ph.D., 1947), Chemical Engineer (B.E.) seeks opportunity to lead research. Accomplished and experienced in carbohydrate, phenolic, lignin, and wood chemistry; wood pulping and pulp bleaching; the directing of research; oral and written communication. Prefer position of large challenge requiring broad interests as well as specialization, initiative and individuality.

E465-59 Wood and Materials Handling Technician—Graduate Forest Engineer with 20 years experience in engineering and wood yard operations, also logging and sawmilling. Desire pulp mill connection. Employed. Excellent references.

Positions Open

P828-59 Wanted ENGINEER—graduate with 2 or 3 years or more experience in piping design for steam plants, paper mills, etc. Location Minneapolis, Minnesota. Steady fulltime only.

P831-59 Midwestern pulp and specialty paper mill requires the services of a young technical graduate with 2–4 years mill experience to carry out an intensive development program. Knowledge of specialty pulps and papers helpful. Excellent opportunity for advancement to Technical Director. Submit complete résumé of education, experience, and salary expected.

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Chemical Engineer or Chemist with paper experience for applications and technical sales work with company selling adhesives to the coated paper trade. Excellent position with well-established company; located Middle West. Please send full résumé to P833-59, Tappi, 155 East 44th St., New York 17, N. Y.

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Internal Sizing with Wax Sizes

R. B. PORTER and J. M. BEHNKE

Almost 25 years have passed since a paper on wax sizes has been presented at the national TAPPI meeting. In fact, it was in 1934 that a paper was given on the use of "Emulsified Paraffin for Paper and Paperboard" (*1*) and in 1935 a paper was presented on the "Bennett System for Preparing Rosin-Wax Sizes" (*2*). To the best of our knowledge no papers on wax size have since been presented. During this interval many types and grades of wax sizes have been introduced to the paper industry and the number of applications has grown considerably. Today somewhat more than 35 million lb. of wax sizes are used annually in the United States by the paper and board industries. Although this volume is considerably smaller than many other papermaking chemicals, it is still a substantial quantity.

BACKGROUND OF WAX SIZES

Although the use of wax sizes for the internal sizing of paper and board has been known for many years dating back to the early use of rosin size, it was not until the 1920's that wax size received serious consideration by the paper industry. The first wax sizes were not actually the wax sizes known today, but rather were combinations of rosin and paraffin wax emulsified together with the aid of beeswax or montan wax saponified with an alkali to form a soap which acted as the stabilizing agent. Laboratory studies and mill trials had shown that when paraffin wax was blended with rosin and emulsified to form a size, the degree of sizing of paper and board was improved over that obtained by the use of rosin size alone. Several grades of rosin-wax sizes containing various ratios of rosin to wax were introduced to the paper industry during the late 1920's and early 30's. These sizes contained various ratios of wax to rosin as well as different grades of rosins and waxes. Special machines were developed for the preparation of the sizes and many of these machines were installed in mills throughout the country. Even today there are a few of the machines still in operation. During the period from the early 1930's to 1940, it became apparent from the practical applications of the rosin-wax sizes that by the separate addition to the stock of a rosin size and a paraffin wax emulsion the degree of sizing could be better controlled and machine difficulties considerably lessened. It was also during this period that the so-called acid stable wax sizes were developed. These sizes offered an improvement particularly with regard to handling and application compared to the nonacid stable types. No longer was there the need of careful control of the pH before addition of the size nor did hard waters have an adverse effect on these sizes. In other words, these sizes are stable over a wide range of pH and are not affected by most electrolytes.

It became evident early that the acid stable-type wax size should always be used in conjunction with rosin size for most papermaking purposes. These wax sizes do not serve as an exclusive sizing agent, although there are some exceptions, but rather produce maximum sizing when used along with rosin size. Experience has shown that the ratio of paraffin to rosin is important to produce a certain desired result in the finished paper or board. The selection of the ratio depends upon the grade of paper produced, the type of wax employed, and in some cases the type of emulsifier used in making the wax emulsion. Continued research and development during the past 10 to 15 years has effected considerable improvement in the quality of the acid stable type sizes and today the greatest volume of wax sizes used by the paper and board industries is of this type.

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WAX SIZES IN EUROPE

Europe has used wax sizes for a number of years and during the war wax sizes were used almost exclusively because of the shortage of rosin. The wax sizes used on the Continent are of the nonacid stable type generally stabilized with the soaps of montan wax or of synthetic waxes produced by the Fisher-Tropsch process. Proteins, such as casein, are used as secondary stabilizers. The waxes employed are, in general, of the straight chain type. However, not only are the paraffins from petroleum used but also synthetic paraffins. These latter waxes are being produced by a polymerization of methane in the presence of an iron catalyst. This type of catalyst produces long straight chain polymerization products of methane. The synthetic waxes are extremely hard compared to the petroleum paraffins and possess a rather high melting point. It might be concluded that the European use of wax sizes differs from that of the United States in that there is a considerably larger use of synthetic waxes which impart to paper or board somewhat improved properties over the petroleum paraffins. For example, the scuff resistance, gloss, and hardness of the paper or board is improved.

TYPES AND GRADES OF WAX SIZES

Today there are some 18 or 20 different grades of wax and rosin-wax sizes supplied to the paper industry. This number appears necessary to meet the requirements of the industry with regard to costs, the properties imparted to the paper or board, and the variations in mill conditions.

The greatest number of sizes belong to the acid stable type with the remainder classified as nonacid stable. Both the acid stable and nonacid stable types are anionic in properties. Nonionic type wax emulsions have not found too great an application in the paper industry since they do not appear to meet many of the necessary requirements.

The major difference between the grades of acid stable wax sizes is the wax itself although there may be other minor differences. The waxes range from a low grade paraffin having a melting point of 120 to 130°F. to the fully refined type as well as a petrolatum and various grades of microcrystalline waxes. Specially refined paraffins are used in one or two sizes for particular applications.

The waxes may be blended with rosin in most any ratio to produce a series of rosin-wax sizes. Generally the uses of these sizes are similar to those of the wax sizes. However, for some applications they do have advantages over the straight paraffin wax sizes. The decrease in strength properties of the sized paper or board is less as is the degree of slipperiness imparted. Also the free rosin content of these sizes appears to have, in some cases, a beneficial effect on the sizing as evidenced for example by an improvement in the lactic acid resistance over a wax size having the same grade of wax as the rosin-wax size. The same waxes may be and are used in the manufacture of the nonacid stable sizes. The differences among these sizes is mainly in the quantity and type of stabilizer. Most of these type sizes are prepared with fatty acid soaps.

ADVANTAGES OF WAX SIZES

Common with many other papermaking chemicals wax sizes have both advantages and disadvantages. Among the advantages might be included:

1. A higher degree of sizing of paper and board compared to rosin size. Generally the sizing is more uniform.

2. The cost for an equivalent degree of sizing is less than for rosin size alone. It has been fairly well established that 60 to 65 lb. of a rosin-wax combination having a ratio of rosin to wax of 80:20 is equivalent to 100 lb. of rosin size.

In addition two other factors contribute to lower cost: (a) lower alum consumption since it is generally true that the amount of alum required is somewhat dependent on the quantity of rosin soap resent, (b) lower drying temperatures may be used for rosin wax sizes than for equivalent rosin size which means lower steam costs.

3. Permanency of paper is improved since wax does not tend to discolor with age. The wax also has a preventive action on the oxidation of rosin.

4. Where foam is a problem as the result of the use of rosin size, wax sizes, particularly the acid stable type, tend to decrease this trouble.

5. Some of the properties imparted to paper and board by wax sizes compared to rosin size include: (a) less tendency to curl, (b) improved finish and fold, (c) improved scuff resistance, (d) improved lactic acid and blood resistance, (e) improved gloss, and (f) improved printing qualities.

DISADVANTAGES OF WAX SIZES

Wax sizes, although they have several advantages for the sizing of paper and board, also have some disadvantages:

1. There is some loss in strength, especially tensile strength, of paper and board when sized with wax sizes.

2. The coefficient of friction is decreased as is the degree of stiffness. However, these two properties can be both an advantage or a disadvantage depending on the end use of the paper or board.

3. Sometimes the use of wax sizes can aggravate pitch troubles more so if the sizes contain a soft, low melting point wax.

4. There have been instances particularly in tightly closed systems where the efficiency of the saveall has been adversely affected.

5. There is a somewhat greater need of technical control for the handling and application of wax sizes than for rosin sizes. Because of the inherent properties of most wax emulsions, the mechanical stability of these products is such that some care must be exercised. Severe pumping action or the action of the jordan can cause a breakdown of the size causing wax spots and sticking on the wire, felts, or press rolls. Build-up or accumulation of wax can occur in the system unless precautions are taken to secure good dispersion of the size throughout the fibers and adequate control of retention. Dilution of the size to 2% concentration or less before adding to the stock assures good distribution while control of the quantity and particle size of the rosin-aluminum complex can have an effect on the wax size retention. Temperatures of the stock when the wax size is added can be important if sticking is to be avoided. Temperatures above the melting point of the wax should not be employed and in no case should live steam be used to warm the stock after the wax size has been added.

Excess wax size over that required to attain the desired end result should not be used as other properties such as strength can be adversely affected.

It can thus be seen that somewhat more careful supervision in the use of wax sizes is required than for rosin size if trouble free operation is to be expected.

MECHANISM OF SIZING WITH WAX SIZES

A survey of the literature will disclose the vast amount of experimentation and study that has been completed in an effort to develop a theory of rosin sizing. At the present time two theories have been proposed to explain, at least to some degree, the mechanism of sizing. One is based on the study of the reaction of rosin soap and alum. The other is based on colloidal phenomena relating to the electrokinetic properties of the sizing system. There has been very little study conducted with wax sizes in attempting to explain the sizing obtained with the use of these products. When the acid stable type wax emulsions are used in conjunction with rosin size, it would appear that both theories as applied to rosin size would offer some explanation. It is quite probable that the rosin size could react in a similar manner as when it is used alone, that is, a rosin-aluminum complex would be formed. The acid stable wax size, because of its composition, would not react with alum and therefore is probably attached to the fiber by electrokinetic phenomena. No doubt a portion is also retained by mechanical action, that is, the filtering action of the wet web on the wire of the paper machine. It is also believed that many of the wax particles are entrapped by the precipitate of rosin soap and alum and are thus retained along with the rosin size.

When the acid stable wax sizes are used as the sole sizing material, sizing is obtained only if alum is also present. In this case it would seem that retention can only be explained by the electrokinetic theory. Without alum, very little, if any, sizing is evident.

With the nonacid stable type sizes, probably the chemical theory offers some explanation since the emulsifier portion of these sizes is generally a soap and would react with alum in much the same manner as does rosin size. Although lacking experimental data, it would seem that the theories of sizing as applied to rosin size are also applicable to wax sizes. Until further study is made of the mechanism of sizing with wax sizes, the theories of rosin sizing will have to be accepted for wax sizes.

WAX SIZE APPLICATIONS

Since the 1920's the number of applications for wax sizes has continued to grow. Although today most mills are familiar with the use of wax sizes it was not always true. Early difficulties with stability and lack of handling know-how made wax sizes a material to be used with caution. However, for today's emulsions, stability difficulties have been largely eliminated, correct handling techniques have been developed and improvements in application know-how have been made. Todays wax sizes possess excellent storage stability compared to those made 10 to 15 years ago. If properly stored, the sizes have been usable even after 5 years. The mechanical stability has been considerably improved so that many of the sizes will withstand the action of pumps or of the jordans. Centrifugal pumps rather than positive displacement or plunger-type pumps are recommended. With the acid stable-type sizes the addition of a small amount of alum or sulphuric acid will improve the mechanical stability. Also warming the size to 100 to 110°F. often permits pumping without a breakdown of the emulsion. As previously indicated, dilution of the size to 2% concentration or less before addition to the stock assures not only better distribution but also decreases any tendency of press roll sticking.

Although wax sizes may be added in the beater or pulper along with rosin size, it is not uncommon to feed the wax size continuously at the machine chest of fan pump. With the acid stable wax sizes alum may be added before or after the wax size. Today, the papermaker can be assured of the right wax size for his particular problem and mill conditions. This is illustrated by some typical examples of the application of wax sizes being used every day in the manufacture of the many grades of paper and board.

Milk Bottle Stock. Considerable wax size is used in the production of milk bottle stock where a high degree of lactic acid resistance is required. It is used in conjunction with rosin size, is of the acid stable type, and generally contains a fully refined paraffin wax since this wax imparts greater lactic acid resistance than the lower grades of paraffin. Normally $1^1/_2$ to $2^1/_2$% rosin size is used with 0.1 to 0.25% of wax size.

Frozen Food Board. Wax size in this type of board imparts high water and lactic acid resistance as well as improving

the bending qualities. Paraffin waxes may be used but generally the more flexible microcrystalline waxes either with or without polyethylene give an improvement in bending characteristics particularly at low temperatures.

The microcrystalline waxes are of the plastic type, generally within the melting point range of 145 to 165°F. The quantities of polyethylene added will depend on the original properties of the microcrystalline waxes. Some microcrystalline waxes are more plastic than others, thus variable amounts of polyethylene may be added for a particular property. The amounts of added polyethylene may vary over a fairly wide range from 5 to 100% based on the weight of the micro wax. The micro wax and polyethylene are blended at elevated temperatures and emulsified by the usual anionic type agents.

Insulating Board. Much of the insulating board made today is sized with a wax size. For this application both the acid stable and nonacid stable-type sizes are used. Preference appears to depend on the individual mill since both types of sizes produce a comparable board. The sizing of insulating board is a typical example where the acid stable size may be used without rosin size. The quantity of wax size used for this type of board varies with the mill's requirements and may range from $^1/_2$ to 2%.

Printing Papers. Wax size when used in conjunction with rosin size imparts to these type papers an improved finish, less tendency to curl and improved printing qualities. The wax decreases the penetration of the ink thus contributing to greater gloss and less ink usage.

Butcher and Meat Wrap. Improved resistance to blood is imparted to this grade of paper by the use of wax size. In several cases a microcrystalline wax size has been found to be better than one containing a paraffin wax.

Calcium Carbonate Filled Paper. By the use of wax size, this grade of paper can be moderately sized and given a smoother "feel."

Cable Wrap. This paper is another example where wax size imparts "hard" sizing.

Asbestos Fiber. Wax size finds an extensive use in the sizing of asbestos fibers. The nonacid stable types are used for this application since the acid stable sizes generally cause considerable foam.

There are numerous other applications for wax sizes. In conjunction with wet-strength resins, for example, they restore some of the pliability lost by the stiffening effect of these resins. In general, wax sizes should be considered whenever a high degree of liquid resistance is required or when particular properties of a paper or board are desired that cannot be obtained by the use of rosin size.

FUTURE OF WAX SIZES

The applications of wax sizes by the paper and board industry, no doubt, will continue to expand as new types and grades of sizes are developed. There are today many grades of waxes that were not available a few years ago and as each of these is evaluated it is quite probable that a new application for wax size will develop. In addition, the combination of waxes with many of the resinous materials has not been fully tested. Wax and polyethylene blends show considerable promise for certain applications where the properties of a polyethylene are desirable. No doubt wax sizes will be improved to show a selective precipitation in that they will be stable to hard waters as well as white water yet be fully precipitated by the action of alum. In this connection it has been found that certain synthetic waxes of very high molecular weight indicate some promise. Also a fortified wax size has been developed which has given encouraging results in improving some of the properties of the standard wax sizes such as retention.

By the blending of paraffin wax with polyethylene some of the properties of the wax can be modified to improve, for example, the low temperature flexibility and toughness. These properties are desirable in certain food boards for good bending qualities at low temperatures and good scuff resistance. The per cent of polyethylene on the wax may be varied from 5 to 100% depending on the final properties desired. Emulsification is accomplished with anionic type agents. The fortified wax sizes are anionic-type sizes and are used either alone or in conjunction with rosin size. Improved retention of these sizes is generally evident compared to standard wax sizes.

There are wax emulsions which impart sizing to paper and board and require no alum. The sizes are cationic active and show good retention by the fiber.

As new grades of paper and board are developed, wax sizes and their modifications will in all probability play an important part.

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Presented at the 43rd Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N Y., Feb. 17–20, 1958.

Basic Properties of Pigmented Coatings Bound with Dow Latex 512-R, Casein, and Isolated Soya Protein

R. L. ERRATT, R. G. JAHN, and L. H. SILVERNAIL

THE use of latex as a paper coating adhesive is now well established. Latex is being used regularly alone and in conjunction with natural adhesives in pigmented paper and board coatings. Certain aspects of the effects of using synthetic and natural adhesives together are known and are being used by the paper coating industry. This paper is intended to supplement and correlate the information concerning the use of Dow Latex 512-R, a styrene/butadiene copolymer, with natural adhesives. The experiment was designed from a practical standpoint with respect to formulation and coating variables and properties tested.

The effect of adhesive composition and level were studied with regard to many of the requirements of coated paper. The information is presented in a consolidated manner which can be used by the industry to obtain desirable properties as a result of formulation changes as indicated by the property trends demonstrated.

EXPERIMENTAL PROCEDURES

Materials Used in Formulations

The following materials were prepared as dispersions or solutions for subsequent use in the pigmented coating formulations. All formulations are solids on solids basis except where otherwise specified. An 80/20 mixture of a medium particle size, coating grade clay and a rutile-type titanium dioxide was dispersed at 70% solids using 0.3% tetrasodium pyrophosphate as the dispersant. A premium grade casein and a low viscosity, isolated soya protein were prepared as 15% solutions. They were solubilized with 10% of concentrated (28%) C.P. NH_4OH. In both cases, the natural adhesive was soaked in water for 5 min. at 140°F. The ammonia was then added slowly and the solutions were cooked an additional 20 min. at 140°F. These casein and soya protein solutions were cooled to less than 100°F. before adding a bactericide for protection.

Dow Latex 512-R was used at 48% solids.

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Formulations for Viscosity versus Solids Determination

It was first necessary to determine the effect of solids on the viscosity of pigmented coating colors bound with various combinations of Dow Latex 512-R and casein or soya protein. From this, the appropriate per cent solids could be determined which would produce coating color viscosities suitable

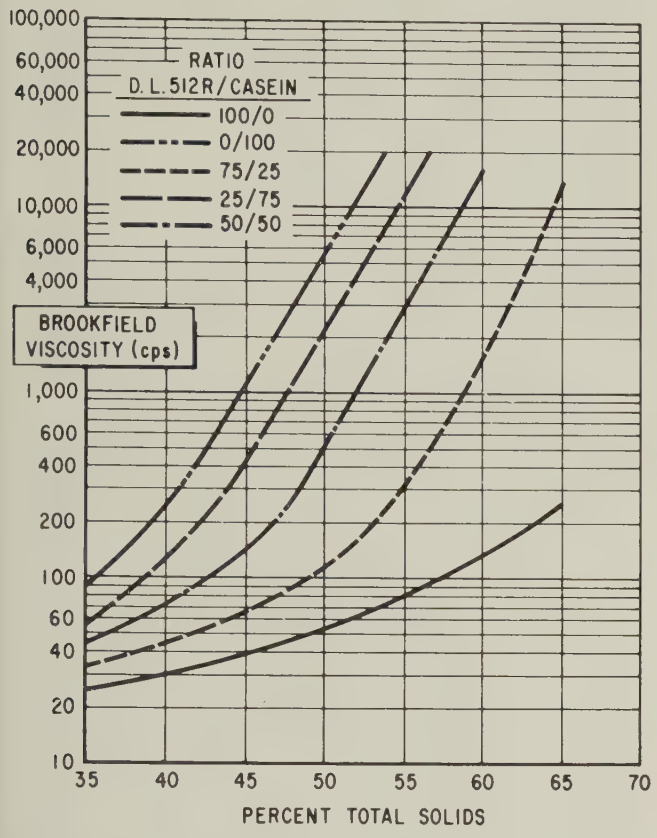

Fig. 1. Viscosity versus solids of pigmented Dow Latex 512-R/casein coating formulations

for application on paper with a wire wound rod. For this determination, high solids formulations were prepared with 100/0, 75/25, 50/50, 25/75, and 0/100 ratios of Dow Latex 512-R/casein and 512-R/soya protein at 15% adhesive level, based on pigment weight. Portions of each of these high solids formulations were then diluted to several solids levels for viscosity measurements.

Preparation of Pigmented Coating Colors

Having determined the per cent solids for the various ratios of synthetic/natural adhesives which would give workable viscosities, pigmented coating colors were prepared at 10.0, 12.5, 15.0, 17.5, and 20.0% adhesive levels (on pigment weight). This was done with each of the five ratios of Dow Latex 512-R/casein and 512-R/soya protein (100/0, 75/25, 50/50, 25/75, and 0/100). Because of the number of formulations and tests involved, it was necessary to run casein and soya protein as separate series. Viscosity versus adhesive level for the various adhesive ratios was determined from these formulations. The coating colors were then applied to paper for testing.

Paper Coating

Coated paper samples were prepared using the above formulations for each ratio of Dow Latex 512-R/casein and 512-R/soya protein at the five adhesive levels. The base stock was bleached sulphite paper—51 lb. per TAPPI ream basis weight. Coating was done with the appropriate wire wound rod for each of the ratios of adhesives (at different per cent solids) to give 15 to 17 lb. per TAPPI ream coating weight. The coated sheets were air dried overnight at approximately 75°F. Calendered sheets were prepared by passing them through three nips on a laboratory supercalender at 1500 lb. per linear in. pressure at room temperature. Coated sheets were conditioned at 75°F. and 50% R.H. before testing.

Testing Procedures

Viscosity versus solids and viscosity versus adhesive level were measured on a Brookfield viscometer (Model RVT) at 100 r.p.m. The adhesive level viscosities for the different adhesive ratios were taken at the per cent solids as prepared for coating.

Coating pick resistance was determined on an IGT printability tester. The coated sheets were aged for 2 days at 75°F. and 50% R.H. and tested at the same conditions. Tests were made with IPI tack graded no. 6 ink with B spring tension and 35 kg. printing pressure on the IGT tester. Strips of each coating were tested in six replicate series, each series covering the complete range of adhesive ratios and levels with one strip of each coating. Test specimens in each series were randomized to reduce time, equipment, and human error variables. The six values for each coating were averaged to determine picking velocity.

The varnish holdout of the various coatings was rated after application of a label varnish diluted with xylene. The label varnish and xylene were blended in 5% increments

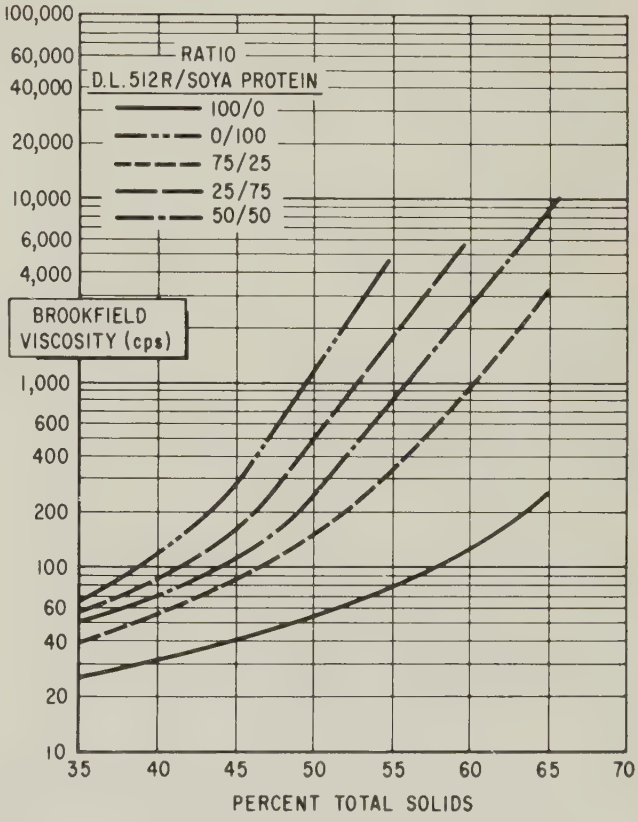

Fig. 2. Viscosity versus solids of pigmented Dow Latex 512-R/soya protein coating formulations

(0/100, 95/5, etc.) and colored with 0.1% of oil soluble red dye. As the varnish content increased in the varnish/xylene solutions, penetration into the coating decreased. A puddle of solution was allowed to stand on the coated side of calendered samples for 30 sec. and then blotted off. Each coating was rated for varnish holdout as the ratio of label varnish/xylene which just penetrated the coating,

causing a red stain on the back of the sheet. Pinholes were not considered as failures.

Gloss measurements were made before and after calendering with a Photovolt reflectance meter (Model 610) using a 60° specular gloss search unit.

Brightness, before and after calendering and after K & N ink application, was determined on a Photovolt reflectance meter. In this case a brightness search unit with a built in no. 49 Wratten filter (blue) was used. The K & N ink receptivity, as indicated by brightness, was determined after applying K & N test ink to the coatings according to TAPPI Routine Control Method RC-19. As the amount of ink absorbed into the coating increased, the brightness decreased.

DISCUSSION

In the results discussed here, the effects of casein and isolated soya protein on the properties of the pigmented coatings were essentially the same. Therefore, except where otherwise discussed, casein and soya protein were considered together. Although a difference in the absolute values of the properties tested may be noted in some cases, the relative values for the different adhesive ratios of the Dow Latex 512-R/casein series and the 512-R/soya protein series, were comparable. Any apparent differences were

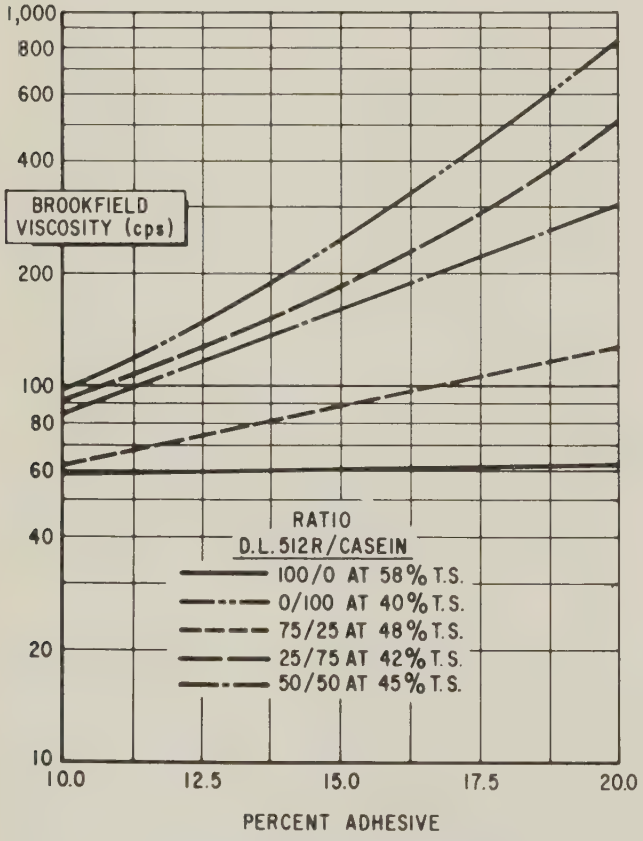

Fig. 3. Viscosity versus adhesive level of pigmented Dow Latex 512-R/casein coating formulations

attributed to unavoidable variations introduced by running the casein and soya protein series separately.

Formulation Viscosities

From the viscosity versus solids data (Figs. 1 and 2) and by coating trials with a wire wound rod, it was established that 58, 48, 45, 42, and 40% solids, for adhesive ratios ranging from all Dow Latex 512-R (58%) to all casein or soya protein (40%), respectively, would produce suitable coating viscosities. The viscosity range and, hence, the per cent solids of the formulations used in this evaluation was determined only with respect to laboratory coating techniques. These viscosities and solids do not necessarily apply directly to other coating methods but similar relationships should hold true for each particular coating operation within the viscosity limitations of the equipment. Figures 1 and 2 also show that viscosity decreased as the

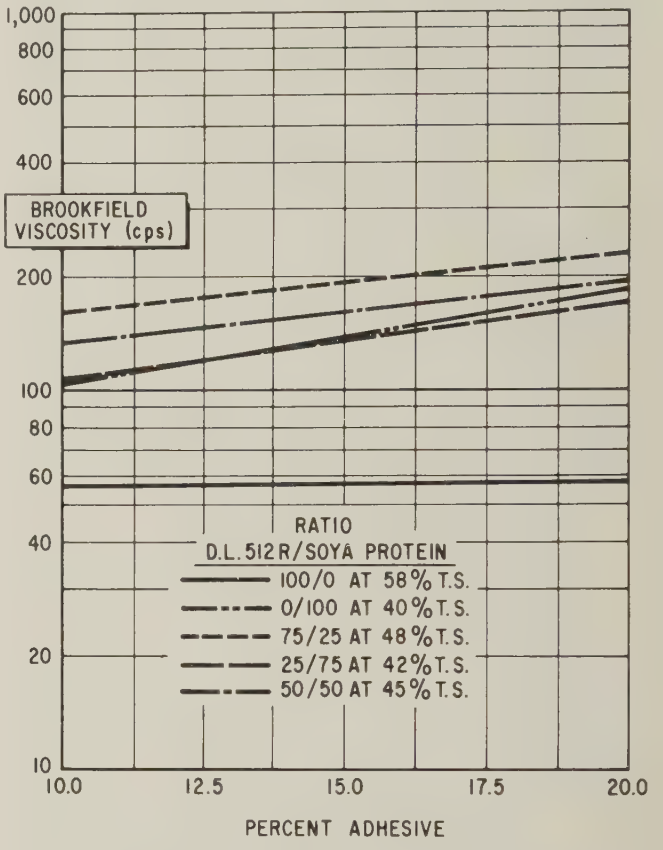

Fig. 4. Viscosity versus adhesive level of pigmented Dow Latex 512-R/soya protein coating formulations

ratio of Dow Latex 512-R/natural adhesive increased at a given per cent solids. The greatest decrease in viscosity, even with increasing solids, was noted in the 100% latex bound coating. This demonstrates that latex can be used to reduce viscosity or increase solids of pigmented coating colors. High solids formulations would result in faster drying, increased coating speeds or heavier coating weights, whichever is desired. The low viscosity grade soya protein gave lower viscosity formulations than casein at the higher solids levels but comparable viscosities in the range used in this work.

Figures 3 and 4 illustrated the effect of adhesive level on viscosity of coating colors. Adhesive level had an almost negligible effect on the viscosities of the all Dow Latex 512-R bound coating colors. The effect increased as the latex/natural adhesive ratio decreased, as indicated by the slopes of the curves. This tendency was more pronounced in the casein series than in the low viscosity, soya protein series. If a higher binder level is required for property reasons, the ratio of Dow Latex 512-R/natural adhesive can be increased and still maintain the desired viscosity range without a reduction in solids.

Coated Paper Properties

The pick resistance of these coatings, as shown in Figs. 5 and 6, was appreciably better when Dow Latex 512-R was the sole adhesive. Combinations of Dow Latex 512-R and

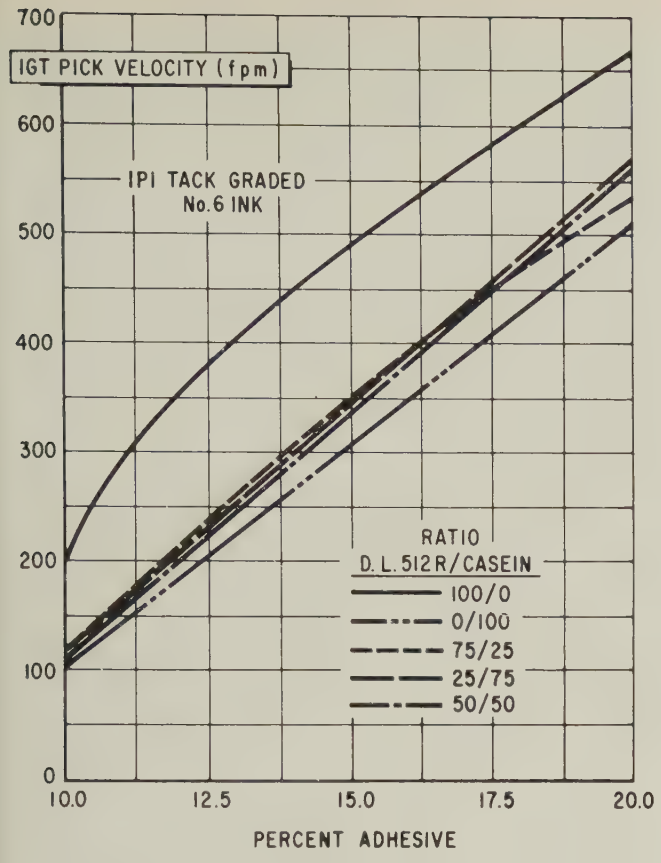

Fig. 5. Pick resistance of Dow Latex 512-R/casein bound pigmented coatings

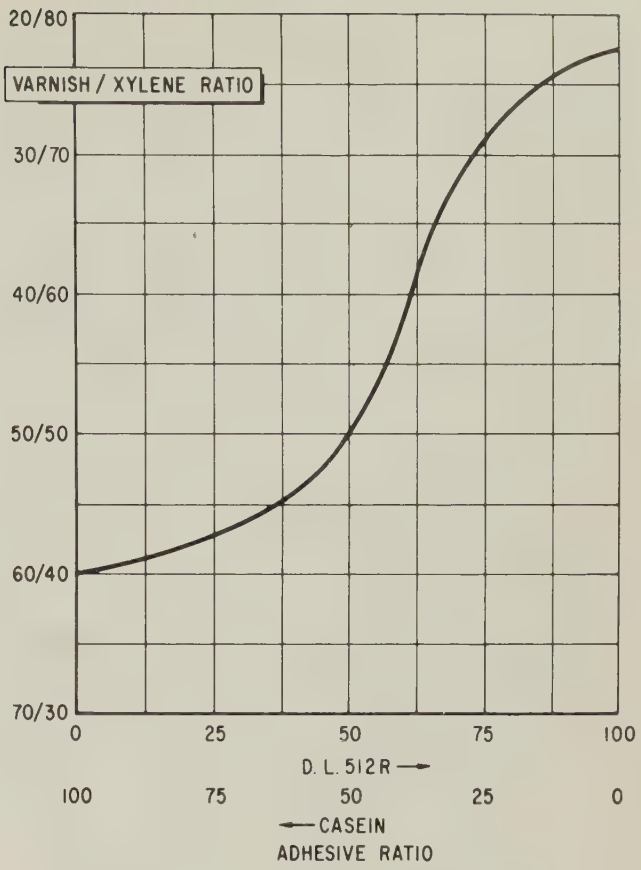

Fig. 7. Varnish holdout of Dow Latex 512-R/casein bound pigmented coatings

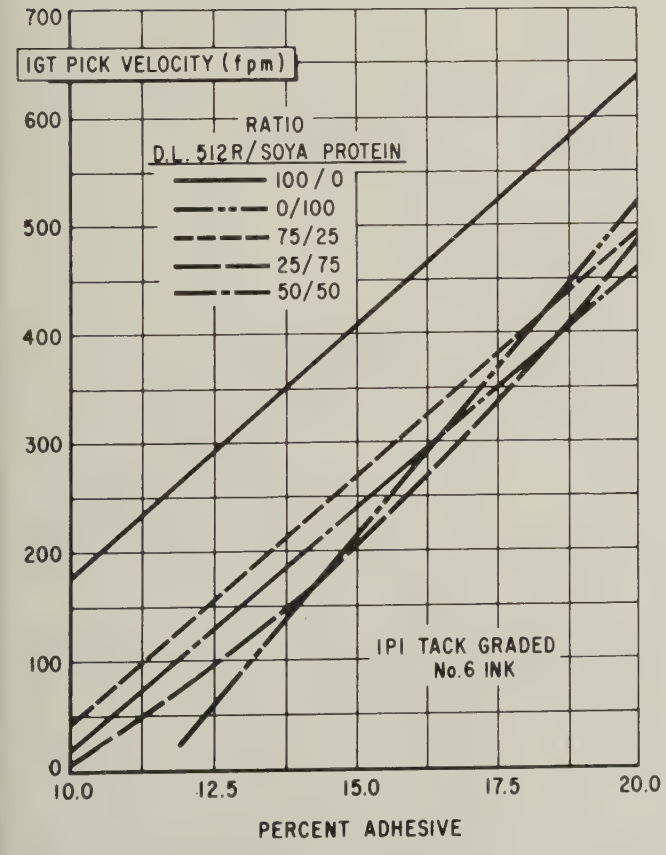

Fig. 6. Pick resistance of Dow Latex 512-R/soya protein bound pigmented coatings

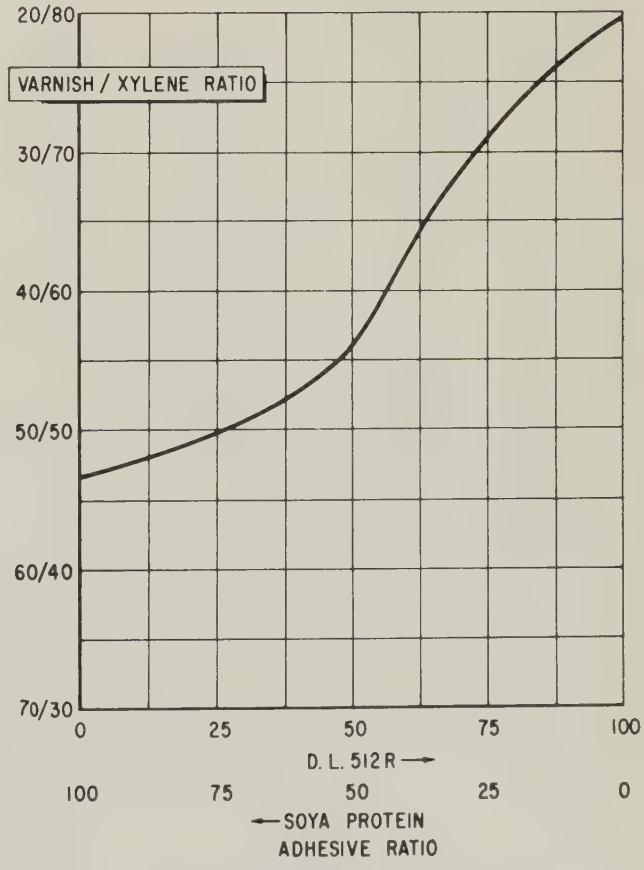

Fig. 8. Varnish holdout of Dow Latex 512-R/soya protein bound pigmented coatings

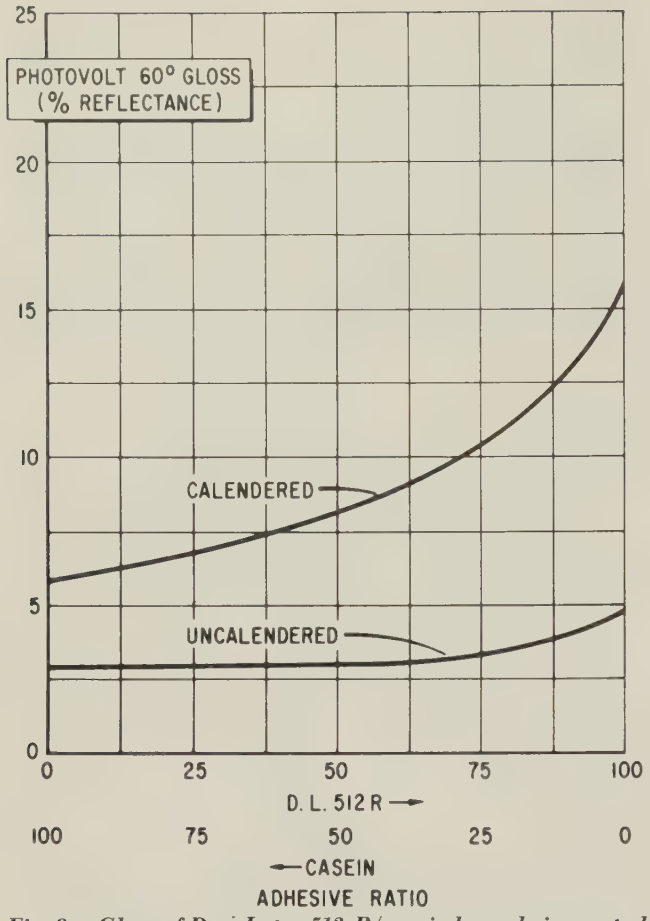

Fig. 9. Gloss of Dow Latex 512-R/casein bound pigmented coatings

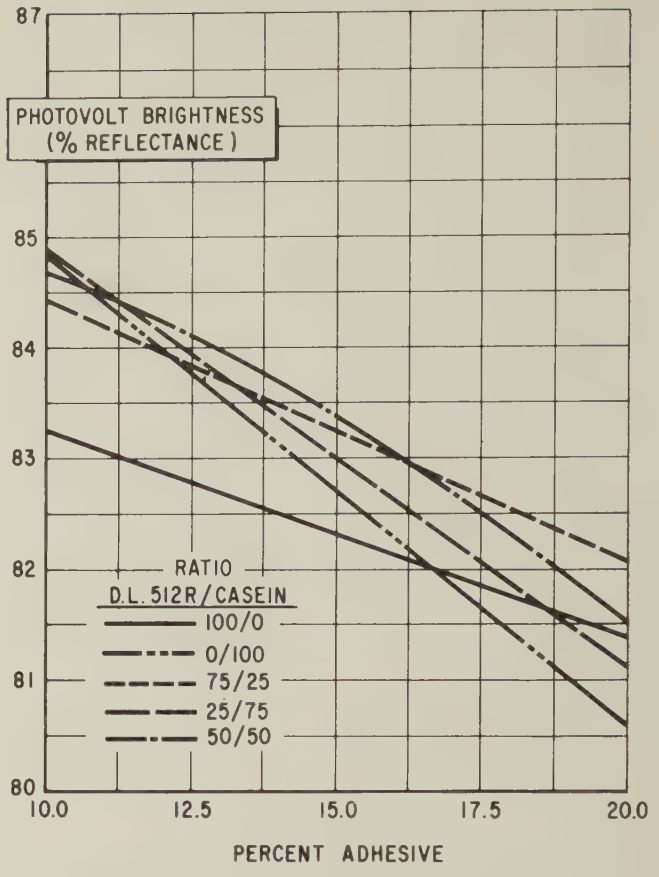

Fig. 11. Brightness of Dow Latex 512-R/casein bound pigmented coatings

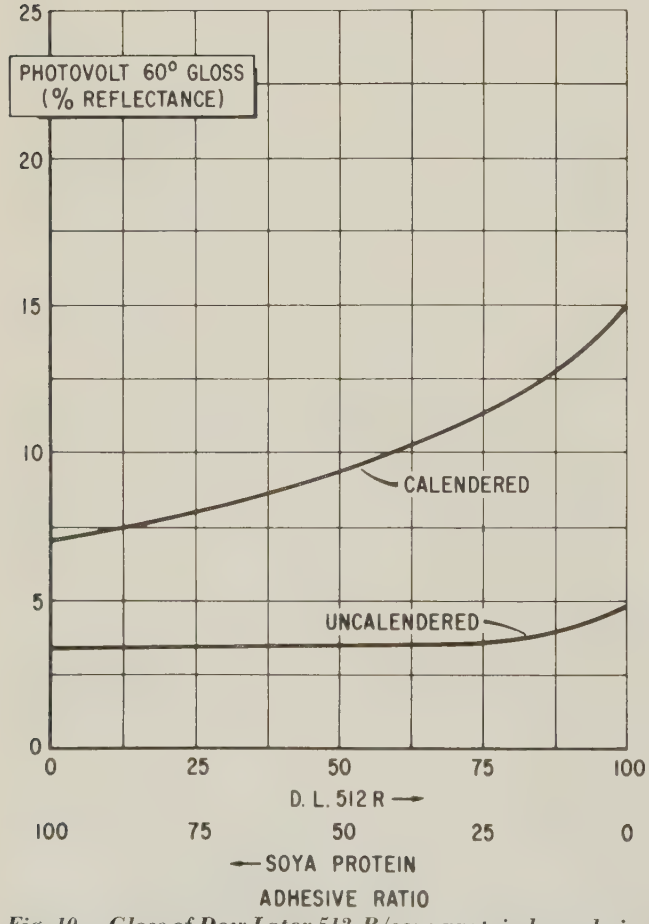

Fig. 10. Gloss of Dow Latex 512-R/soya protein bound pigmented coatings

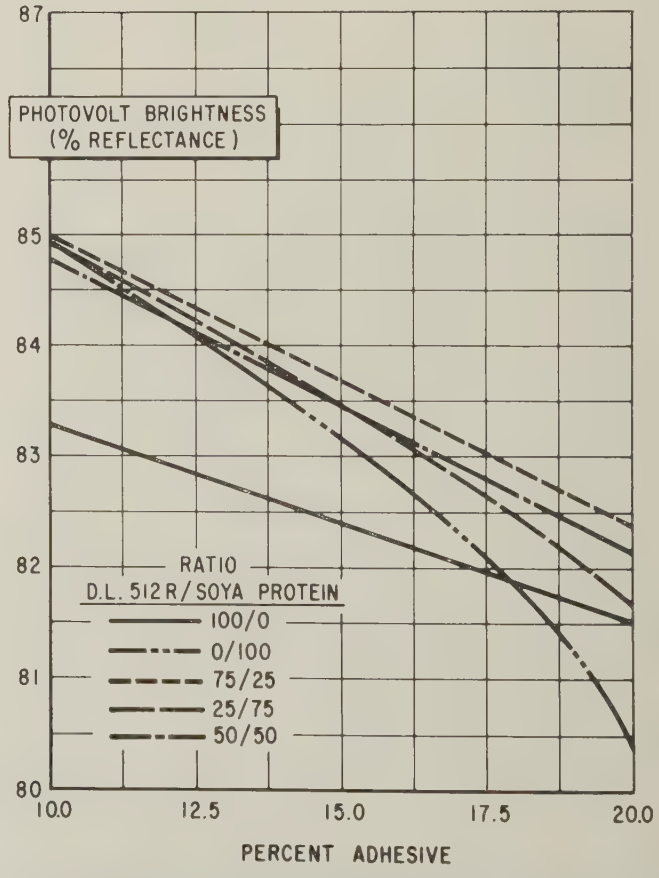

Fig. 12. Brightness of Dow Latex 512-R/soya protein bound pigmented coatings

the natural adhesives, or the natural adhesives alone, produced pigmented coatings with approximately equal pick resistance. The effect of increasing pick resistance by increasing the Dow Latex 512-R used in conjunction with the natural adhesive is not too apparent in these data. However, the coatings were tested after only two days aging. Previous laboratory work and field experience have demonstrated that Dow Latex 512-R increases in pigment binding efficiency with aging. The aging effect would increase the pick resistance of the coatings according to the per cent of Dow Latex 512-R in the adhesive system. The pick resistance of these coatings varied directly with the adhesive level and was essentially a straight line function over the range of adhesive levels tested. This was verified by statistical analysis.

Figures 7 and 8 show a decided improvement in varnish holdout obtained as the ratio of Dow Latex 512-R/natural adhesive increased, especially above 50% latex. These curves, in each case, represent an average of the five adhesive levels evaluated. As would be expected, varnish holdout also increased with increasing adhesive level. The individual curves for each adhesive level were similar to the average curves shown here, but displaced according to the binder level. The extremes of adhesive levels and ratios approached the limits of the test method (especially maximum) and accounted, at least partially, for the leveling of the curves. The improvement in varnish holdout which resulted from increased levels of latex in the adhesive is also known to hold true for lacquers and gloss inks.

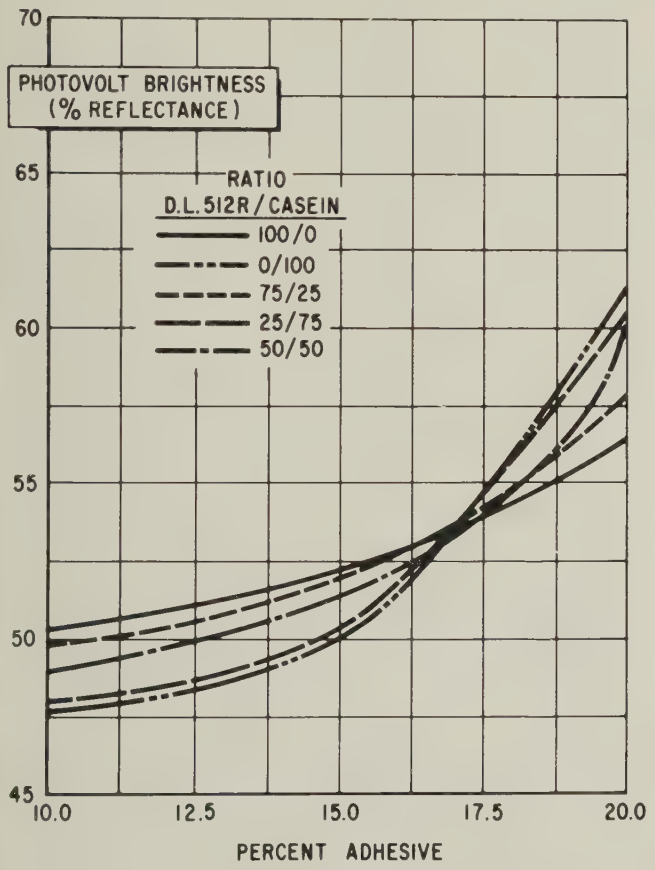

Fig. 13. K & N ink receptivity of Dow Latex 512-R/casein bound pigmented coatings

Figures 9 and 10 show the increasing effect of calendering on the gloss of the pigmented paper coatings as Dow Latex 512-R increased in the adhesive ratio. The latex copolymer is somewhat thermoplastic, in contrast to the harder, more brittle natural adhesives, and this is responsible for the improved finish as the latex was increased in the adhesive system. These curves also represent the average of five binder levels. The individual curves were again similar to the average curve but, in this case, decreased slightly as the binder level increased.

In Figs. 11 and 12, it can be seen that the brightness of the pigmented coatings decreased as the adhesive level increased.

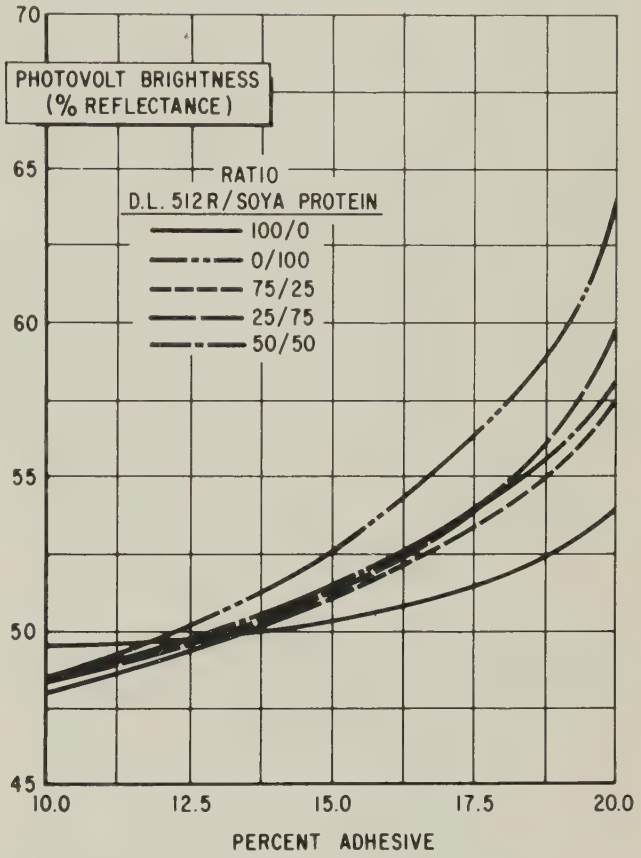

Fig. 14. K & N ink receptivity of Dow Latex protein bound pigmented coatings 512-R/soya

This effect was less apparent on the coatings bound with all Dow Latex 512-R than those with the natural adhesive.

Although the Dow Latex 512-R coatings had lower brightness at the lower adhesive levels than the all casein or soya protein bound coatings, the latex coatings were equal or higher in brightness at the higher adhesive levels, which are in common use. An interesting point here was that the coatings bound with combinations of Dow Latex 512-R and natural adhesives, especially 75/25 and 50/50, had higher brightness than coatings utilizing either adhesive alone. Calendering had negligible effect on the brightness of any of these coatings.

The ink receptivity of the pigmented coatings decreased, as indicated by increased brightness, as the adhesive level increased (Figs. 13 and 14). In this comparison, Dow Latex 512-R bound pigmented coatings showed less change in ink receptivity over the range of adhesive levels tried than the natural adhesive bound coatings. The K & N ink receptivity of coatings prepared with the combinations of adhesives fell at intermediate levels. These data illustrate one of the important reasons for using latex in an offset coated paper. The adhesive level of Dow Latex 512-R can be increased to produce the required cohesive strength of the coating without a great decrease in ink receptivity such as noted in the higher levels of the natural adhesives.

CONCLUSIONS

A number of conclusions can be drawn from the results

presented above. Increasing the per cent Dow Latex 512-R present in the adhesive system will produce pigmented coating colors at considerably lower viscosities and/or higher per cent solids. This effect is especially significant where latex is used as the entire binder. The adhesive level of an all Dow Latex 512-R bound coating color can also be increased with negligible effect on viscosity. With latex/natural adhesive combinations or natural adhesives used alone, increasing binder level will appreciably increase the coating color viscosities.

The pick resistance of pigmented coatings can be decidedly increased by using Dow Latex 512-R as the sole adhesive. Substitution of casein or soya protein for part or all of the Dow Latex 512-R adhesive will require an additional 2 to 3% total adhesive to produce pick resistance equivalent to that obtained with the all latex bound coatings.

Increasing the ratio of Dow Latex 512-R/natural adhesive will increase the varnish, lacquer, and gloss ink holdout and also the gloss of calendered coatings. Partial substitution of casein or soya protein for latex, up to a maximum of approximately 50%, will produce coatings with higher brightness than with either the latex or natural adhesive used alone. The decrease in ink receptivity which results from increasing adhesive level can also be reduced by increasing the Dow Latex 512-R/casein or soya protein ratio in the adhesive system of the coating.

Presented at the 9th Coating Conference of the Technical Association of the Pulp and Paper Industry, Bedford Springs, Pa., May 14–16, 1958.

Microorganism and Odor Control in Pulp and Paper Manufacture by Use of Stabilized Chlorine Dioxide

NORMAN ALPER

Chlorine dioxide, known for the past hundred years, and commerically available for the past 12 years or more, is a red-yellow gas, prepared by reaction of several known chemical combinations. It decomposes in sunlight and detonates when heated rapidly to 100°C. Liquid chlorine dioxide is red and explosive (*1*). Chlorine dioxide in water solution will not explode (*2*).

STABILIZED CHLORINE DIOXIDE

Dioxcide is a complex formed by introducing gaseous chlorine dioxide, prepared by a standard method, into an aqueous solution of sodium perborate. This complex is not toxic nor does it possess the explosive or other undesirable characteristics of chlorine dioxide. The chlorine dioxide is held in the form of a labile complex with the boron compound. The solution does not undergo the usual rapid decomposition of chlorine dioxide in water (*3*).

The pH of this product ranges from 6.5 to 7.0. Upon lowering the pH, the chlorine dioxide is released from the perborate, the extent of release depending on the pH reached. For example, at a pH of 2.0 approximately 84% of the original chlorine dioxide strength is released within two hours; at a pH of 4.0 only 1% is released within the same two-hour time. The released chlorine dioxide remains dissolved in the water. The solubility of chlorine dioxide in water is ten times that of chlorine (*4*). In this released state, Dioxcide reacts very similarly to an aqueous solution of chlorine dioxide.

The stabilized material, Dioxcide, has been shipped in various size containers, stored under varying conditions, and used, with no unusual care, in a number of industrial applications.

The stabilized chlorine dioxide complex is colorless to slightly yellow and is practically odorless. The active ingredients of the product is 40,000 p.p.m. and it is completely miscible in water in any proportions. Dioxcide has a specific gravity of 1.074 and a pH of 6.5 to 7.0. Stability in storage is excellent at temperatures ranging from 40 to 120°F.

OXIDIZING AGENTS AS GERMICIDES AND DISINFECTANTS

Oxidizing agents, as disinfectants and germicides, are dependent on the reactivity of oxygen for their effectivity. The extreme reactivity of nascent oxygen acts in a number of ways: by reaction with cell structure, by reaction with proper balance, and by speeding up the metabolism to the detriment of cell growth (*5*).

Compared with chlorine, chlorine dioxide has five reactive electrons whereas chlorine has one. In some waters, in addition to chemical tastes and odors imparted by phenol and other industrial wastes, there is present a woody, musty, or swampy taste caused by algae or decayed vegetation. This is commonly found in surface waters during the summer months. It has been indicated by Silvey (*6*) that actinomycetes may be the actual cause of these particular tastes and odors. Although higher dosages of chlorine dioxide have been required, in some cases, to control this type of taste and odor, the powerful oxidizing action of chlorine dioxide provides positive control with applied dosage in an economic range.

In contrast to chlorine, the sporicidal and bactericidal efficiency of chlorine dioxide is relatively unaffected by pH values between 6.0 and 10.0. This would indicate important application in waters of high alkalinity, softened waters, and waters treated to prevent corrosion. The spore forming organisms are a notable source of troubles as they may provide aftergrowths in the distribution systems. The maintenance of a free available residual in the distribution systems is considered good practice since it provides a measure of protection in water transmission lines. One of the most important characteristics of chlorine dioxide is its ability to provide and to maintain such a residual throughout distribution systems (*8*). Surveys of municipal water systems employing chlorine dioxide have shown chlorine dioxide residuals to persist through open reservoirs and on out to the very ends of distribution lines.

OXIDATION WITHOUT CHLORINATION

The nature and the degree of pollution of water plays an important part in the economic picture of water treatment. Whereas chlorine reacts first to form chlorine products such as chlorophenols in waters containing phenol, and chloramines in waters containing ammonia, chlorine dioxide acts primarily as an oxidizing agent or as one observer expressed it "Chlorine dioxide gives oxygenation without chlorination" (*9*). In water containing phenols, chlorine will react to form chlorophenols until a sufficiently high dosage of chlorine is applied to break the ring and form tasteless and odorless compounds. Chlorine dioxide by its direct oxidation of the phenol breaks the phenol down to odorless and tasteless compounds without forming the intermediate products. These intermediate products are often of greater objection than the original phenol or other contaminating chemical.

The same situation exists with waters in which algae and actinomycetes are present. Algae give off certain chemical compounds, which, upon chlorination, form chloro-compounds that are much more objectionable than the original. In the case of actinomycetes, one of the products of decomposition is butylamine. This product does not yield to chlorina-

Norman Alper, Director of Industrial Sales and Market Development, Chemical Research Laboratories of America, Inc., Lafayette, R. I.

tion in any reasonable dosage. The odor becomes more intense with increasing dosages of chlorine. Chlorine dioxide, however, will oxidize this taste and odor producing compound to one that is completely inoffensive (*10*).

Another characteristic of chlorine dioxide, of importance from the standpoints of bacterial and odor control, is the inability of chlorine dioxide to react with ammonia. In waters of high nitrogen content, less chlorine dioxide than chlorine is required to produce a free residual. Here, too, as with phenols, the chlorine dosage must be sufficiently high to satisfy the ammonia demand before it becomes available for sterilization, taste, or odor control purposes.

As chlorine dioxide is not apt to combine with other chemical components of water supplies, its full power can be exerted on organic material with far greater efficiency and lower demand. It may well be that the chlorine dioxide has a selective action or attraction to proteinaceous organic material. This is along the lines of preferential adsorption wherein the bactericidal power of chlorine dioxide, by elimination of side effects or wasted power, and also by its complete water solubility and attraction for organic materials, give very rapid biocidal action. Prolonged contact time is not necessary.

Dioxcide, readily dispersed through the water system due to its complete solubility, provides chlorine dioxide *in situ* throughout the water lines. The release of chlorine dioxide from the labile complex and the level of activity can be governed and extended over a predetermined period of time. A residual of the active ingredient, chlorine dioxide, can be built up in the system and maintained at a set level without unnecessary or unwarranted dissipation on nonbactericidal side reactions.

As mentioned previously, adjustment of pH can speed or reduce the release of chlorine dioxide from the complex, Dioxcide. A second release factor is the triggering effect of residual chlorine on Dioxcide. This may be utilized to speed release of the labile chlorine dioxide in a system where a chlorine residual is known. By introducing Dioxcide into water containing chlorine residual, release of chlorine dioxide can be effected at points of advantageous application, and at controlled rates where the action of the chlorine dioxide will be of greatest value.

Dioxcide, in use, is being metered into both water systems and paper machines by use of air, water, or electrically actuated pumps. Through accurate application, a residual is maintained in the systems based on the water intake, recirculated water volumes, and the effluent on the paper machines system.

Among the most interesting characteristics of Dioxcide is the nontoxic and nonirritating nature of the material. The chlorine ion itself is nontoxic. Compounds of chlorine, such as chloramines, produced by the combining of chlorine and ammonia, or chlorophenols, produced by the combining action of chlorine and phenols, are highly toxic to man. Since chlorine dioxide does not combine with other chemicals to form chlorine compounds, it does not become toxic in use.

TEST DATA

Before producing Dioxcide for commercial use as a germicide, exhaustive tests were conducted on laboratory-produced product to determine its efficiency and economic potentials.

Initial studies of Dioxcide indicated that standard methods employed for examination of germicides could not be used to test this complex. Attempts were made to set up a phenol coefficient for the material and it was found that this method of comparison was unsatisfactory.

The seeded plate method and the dilution method using phenol mercuric acetate for comparison purposes were tried. Again, they did not offer a good method for the examination of stabilized chlorine dioxide. It has been pointed out by Ralph T. Russell of the Microbiological and Biochemical Research Center of the Syracuse University Research Institute that "germicides act in a variety of ways and their efficiency is influenced by the environment in which they are to be used." It was felt that the use of mill white water in sufficient volumes to simulate actual conditions is a much more accurate way to determine the germicidal efficiency of a product to be used in a mill.

The tests were carried out in mill water obtained from a paper mill. The hydrogen ion concentrations were altered to suit the needs and varied from pH 7.0 to pH 4.5. (The pH of most mills will vary between these two levels depending on the use of sizing agents.)

Final tests were carried out in the Syracuse fermenter using 5 l. of paper mill white water. This unit was considered to more closely approximate mill conditions than any other method of testing. The germicide was added to the units and the germicidal power of Dioxcide was measured by determining the rates of death of the organisms in white water and the time required to kill all the organisms present. The preparation of all media, diluting, plating, and counting was carried out as prescribed in standard methods.

At pH 4.5 to 5.5 Dioxcide was found to be very efficient. Effective or total kill was noted in 2 hr. time, with as low as 5 p.p.m. of the active material in the germicide (ClO_2). In testing, it was felt that the germicide should result in maximum kill within a 4-hr. contact time. This is based on the usual contact time in a mill system. The results indicated that total kill was effected in approximately 2 hr. depending on the pH of the media.

As in all germicides, the point of application is of utmost importance together with the rates and method of feeding the material into the mill system. These must necessarily be determined in accordance with individual mill and machine conditions.

Of special note is the adaptability of Dioxcide for the treatment of fresh water supplies. In this application, a measurable residual can be carried into the white water systems and be recirculated throughout the cycle of the paper machines.

Preliminary investigation and mill use indicates that Dioxcide is not unduly substantive to fiber and the material will remain in the waters. Cost estimates are based on the volumes of water in use, regardless of whether it is recirculated or goes out as effluent. Accordingly, the greatest advantage should accrue to the most closed mill systems.

In conclusion of this preview of a product, at our present stage of progress, it is believed that Dioxcide has shown properties and potential promise to enable the pulp and paper mills to effect further closing of their water supplies, to utilize more recirculated waters and to improve both their product and working conditions.

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Presented at the 43rd Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 17–20, 1958.

Factors Affecting Strength of Paper Honeycomb

FRED B. SHAW and HARVEY C. LISLE

EVEN if we choose to disregard the bees that contributed the fundamental design, honeycomb is not new as either a structural or decorative material. Paper honeycomb and processes for manufacturing it are old; older than the thermosetting plastics industry which frequently considers the entire honeycomb business a recent offspring of its own creativity.

In 1904, 5 years before the issuance of Baekeland's basic patent no. 942,699, one Dagobert Budwig of Berlin, Germany filed a U. S. patent application which discloses a method for making paper honeycomb, which is not essentially different from the procedures used today. In his patent, no. 765,412, Budwig describes a procedure for applying adhesive node lines to a continuous paper web which he states is an improvement over "the process heretofore known." Budwig makes no statements as to the use of the products of his process but it is assumed the material was chiefly used in decorative items, such as the well-known Christmas bell. However, there is an even earlier patent reference to the use of "polygonal cells" as a core structure between two facing sheets to provide "an improved body or material for use in or on walls, partitions and like places to prevent the passage of sound, heat or cold . . . to supply in a ready, cheap and convenient form a sectional body of nonconducting material having the properties of readiness of application (i.e., prefabricated), cheapness of construction, and lightness in handling." This U. S. patent, no. 369,796, entitled "Non-Conducting Filling or Lining" was issued in 1887 to a very forward-looking citizen of Chicago named George Kelly.

There is no record of either Kelly or Budwig having ever capitalized on their inventions. In fact, the commercial availability of structural paper honeycomb is relatively recent. Though old in years, paper honeycomb is still an infant. It has promise of being a basic engineering material, but it is still seeking its major markets.

The slow growth of the honeycomb industry has been partially due to the fact that high strength to weight ratio materials were not in great demand until the rapid expansion of the aircraft and related industries during World War II emphasized the necessity for such products. Even more directly responsible for honeycomb's slow growth has been the lack of sufficient engineering data to encourage designers to make use of the material.

A significant effort to overcome this deficiency of data has been made by the aircraft industry and the Forest Products Laboratory, in the cases of metallic honeycomb and reinforced plastic honeycombs. But the oldest member of the family, paper honeycomb, has not shared in this effort. Methods for manufacturing the product have received much more attention than the characteristics of the product itself, with the result that the three commercial manufacturers of paper honeycomb must now direct their efforts to a fuller understanding of this material if their present productive capacities are ever to be taxed, let alone expanded.

We at Continental Can Co. are, of course, vitally interested in bringing the promise of paper honeycomb to fruition and in sharing in the harvest which we feel will result when this product finds its proper place in the list of materials of construction. Toward this goal we have been making an extensive study of the raw materials and the process variables pertinent to paper honeycomb. Results of some of these investigations are summarized in this paper.

Prior to presenting any findings, however, a brief description of the manufacturing process is in order. While process details will vary from company to company, all methods have in common the initial step of printing continuous parallel lines of adhesive on the web which will form the basis of the final structure. The paper web may be a bleached or natural kraft of any of a wide variety of basis weights, but most commonly 60, 80, or 99 lb.

Many different types of natural kraft have been successfully used including MF kraft, bag and gumming grades, with all degrees of surface finishing. The use of coated, impregnated, or laminated papers is also feasible. As an additional variable, impregnation may be accomplished on the base paper prior to conversion to honeycomb, during the expanding operation, or as a final operation on the otherwise fully formed product.

Node line adhesives may be either thermoplastic or thermosetting, provided only that they will hold during the expanding operation and in service. Urea, resorcinol, and neoprene rubber-base compositions are the most commonly used.

The distance between node lines, of course, determines cell size. The width of the node lines can be varied to some degree. The narrower the node line, all else being constant, the lower the density of the resultant honeycomb; but excessively narrow node lines make subsequent manufacturing operations more difficult. As a compromise, a $^1/_{16}$ in. width is typical.

After the web has been printed, it is sheeted and stacked in such a manner as to bring the nodes of the ruled sheets in vertical alignment, in such a manner that the cells of the final product will be regularly positioned in both directions.

If thermosetting node adhesives are used, it is next necessary to heat cure the printed stack of sheets under some slight pressure. This step is not required if a thermoplastic adhesive has been used.

In any case the stock is then ready to be sliced, the width of each slice being the thickness of the desired honeycomb panel; the so-called T dimension. Commercially the T dimension is available from $^1/_2$ to 6 in.

The technique of slicing depends primarily on the height of the block of unexpanded sheets. If this is limited to a relatively few inches, slicing may be accomplished by use of a sheet metal shear. However, if the block is substantially over 4 in., slicing must be accomplished by especially designed saws.

Slices of unexpanded honeycomb may be expanded individually, or they may be cemented together, leading edge to trailing edge, and then expanded on a continuous basis. When expanded continuously, the material, if desired, may be passed through a resin solution at the start of the operation so that the expanded honeycomb may be freed of solvent, heat-set, and have its absorbed resin cured, simultaneously.

A successive, in-line operation may thereafter continuously apply any desired facing material such as paper, rein-

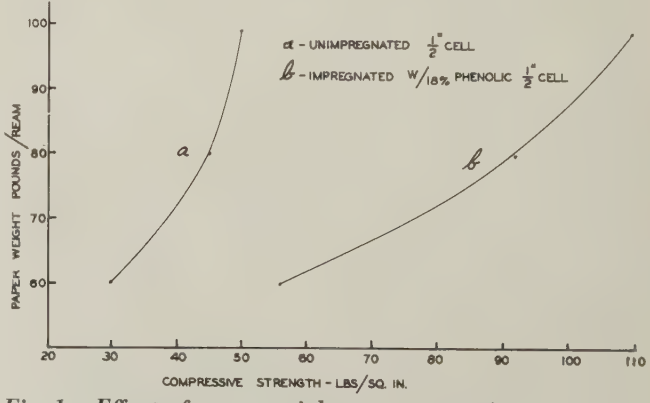

Fig. 1. Effect of paper weight on compressive strength of honeycomb

FRED B. SHAW, General Manager, and HARVEY C. LISLE, Honeycomb Project Engineer, R & D Dept., Flexible Packaging Div., Continental Can Co., Inc., Mt. Vernon, Ohio.

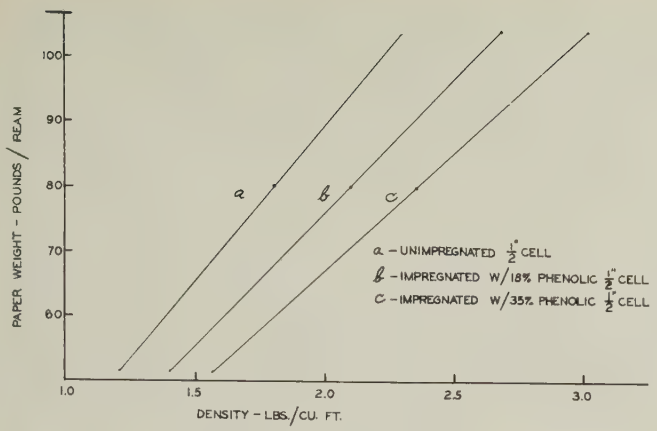
PAPER WEIGHT - POUNDS / REAM
DENSITY - LBS./CU. FT.
a - UNIMPREGNATED 1/2" CELL
b - IMPREGNATED W/18% PHENOLIC 1/2" CELL
c - IMPREGNATED W/35% PHENOLIC 1/2" CELL

Fig. 2. Variation of honeycomb density with paper weight [theoretical]

forced plastic laminate, or aluminum to either one or both faces of the expanded honeycomb to produce a finished sandwich construction, if desired. However the many additional variables introduced by this latter operation are not pertinent to the present discussion.

Since honeycomb is a device produced primarily to provide maximum physical strength at minimum density, the correct selection of component materials and detail dimensions involves continual compromise. For example, Fig. 1 illustrates graphically the effect of basis weight of the paper used on the compressive strength of honeycomb, both in the case of the unimpregnated and the phenolic resin impregnated (18%) varieties; while Fig. 2 provides corresponding data on honeycomb density for the same series of constructions. Since density increases linearly with increase in paper basis weight in either case shown (i.e., unimpregnated or impregnated) while compressive strength is seen to be a parabolic function of paper basis weight, the strength-weight ratio decreases as compressive strengths (and other fundamental strength properties) increase. These data, however, are typical only of material at approximately 70°F. and 50% R.H. Under other special conditions, as mentioned below, a very significant increase in the strength-weight ratio can be attained by using some of the higher density materials.

Means of enhancing physical properties other than increasing the basis weight of the paper stock used include decreasing the cell size and/or increasing the resin content of impregnated stock. The effects of these variations are reflected in Figs. 3 and 4, respectively, and once again show that the cost of continually increased performance is continual decrease in the strength-weight ratio.

Since compressive strength is of paramount importance

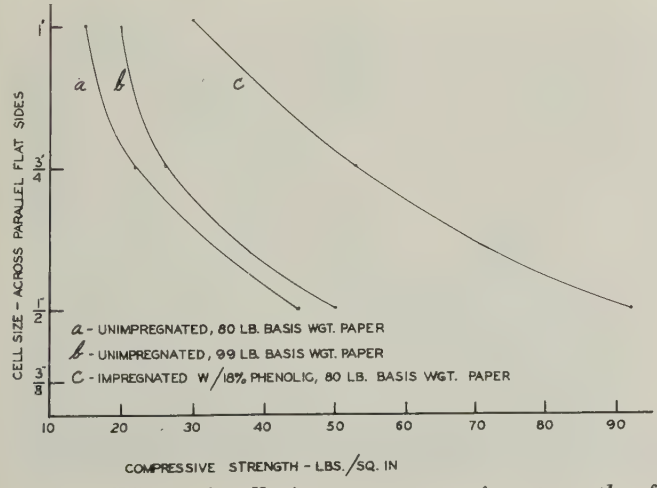
CELL SIZE - ACROSS PARALLEL FLAT SIDES
COMPRESSIVE STRENGTH - LBS./SQ. IN
a - UNIMPREGNATED, 80 LB. BASIS WGT. PAPER
b - UNIMPREGNATED, 99 LB. BASIS WGT. PAPER
c - IMPREGNATED W/18% PHENOLIC, 80 LB. BASIS WGT. PAPER

Fig. 3. Effect of cell size on compressive strength of honeycomb

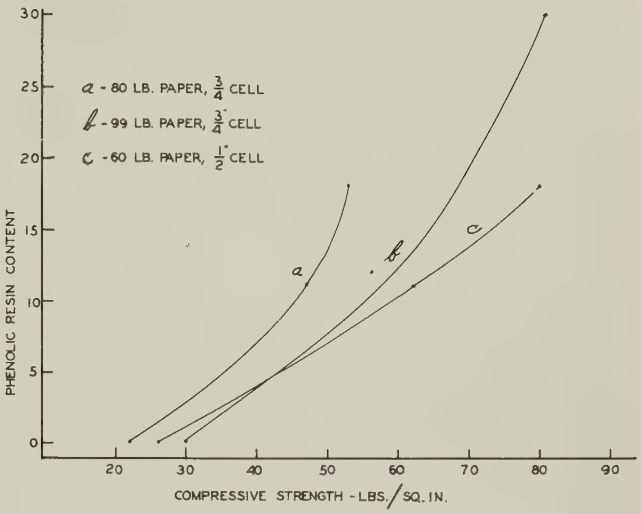

Fig. 4. Effect of phenolic resin content on compressive strength of honeycomb

in many paper honeycomb applications, this characteristic has been stressed. But the same relationships hold true for several other physical properties such as flexural strength, as shown in Fig. 5.

Minor physical improvements are attainable in every classification by the use of a stiffer paper, such as gumming stock, in lieu of MF kraft. Exemplifying data are shown in Table I.

Table I. Effect of Type of Paper Stock on Physical Properties

(All samples 60 lb. basis weight, 1/2-in. cell size)

Paper stock	*Phenolic resin, %*	*Compressive strength, lb./sq. in.*	*Flexural strength, lb./in.* W	L
MF kraft	0	30	..	..
Gumming	0	38	..	..
MF kraft	17	56	29	60
Gumming	17	66	29	63
MF kraft	20	75	38	55
Gumming	20	..	38	54

Another source of minor improvement is available in the case of impregnated types by impregnating the paper with the selected resin prior to any converting operation, rather than during the expanding or as a terminal step. The reason for this is presumed to stem from the more uniform resin distribution and possibly better resin cure that results from utilizing the preimpregnating process. Comparisons of similar products made by the preimpregnation and post-impregnation methods are provided in Table II.

Early in our development work with paper honeycomb it

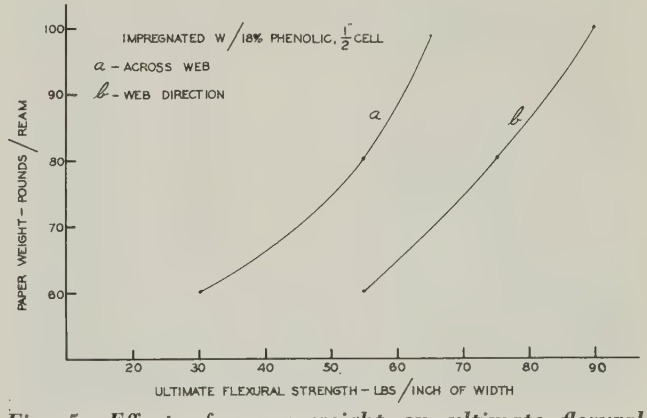
PAPER WEIGHT - POUNDS / REAM
ULTIMATE FLEXURAL STRENGTH - LBS / INCH OF WIDTH
IMPREGNATED W/18% PHENOLIC, 1/2" CELL
a - ACROSS WEB
b - WEB DIRECTION

Fig. 5. Effect of paper weight on ultimate flexural strength of honeycomb

Table II. Comparison of Pre- and Postimpregnated Honeycomb

(All samples MF kraft)

Basis weight, lb.	*Phenolic resin, %*	*Impregnator stage*	*Cell size, in.*	*Compressive strength, lb./sq. in.*	*Flexural strength, lb./in. W*	*L*
80	18	Post	3/8	105	61	84
80	18	Pre	3/8	116	118	132
99	11	Post	3/4	62	...	...
99	11	Pre	3/4	90	23	42

was felt that the products brightest future lay in its use in producing a low-cost disposable shipping pallet as illustrated in Fig. 6. For example, using honeycomb with $^1/_2$-in. cells formed from unimpregnated 80-lb. MF kraft paper, a compressive strength of 45-lb. per sq. in. is obtained. Therefore, if nine 8 by 8-in. posts were cemented to a corrugated deck, we should theoretically be able to support a 25,000-lb. load.

Initial trials were most promising and numerous successful shipments were made. But the problem of humidity was not given sufficient emphasis. During summer weather it was found that loads had a tendency to compress the honeycomb over long periods of time. Obviously, the increased moisture content of the paper was decimating the compressive strength. In fact, exposure to rain or liquid condensation in a warehouse lowered the compressive strength virtually to zero.

To overcome this handicap, resin impregnation appeared to be the obvious answer, and, in fact, the wet compressive strength of $^3/_4$-in. cell honeycomb formed from 99-lb. MF kraft increased markedly with increased resin content, as shown in Table III.

However, this approach does not appear to be the entire answer to the problem since the use of 18% of phenolic

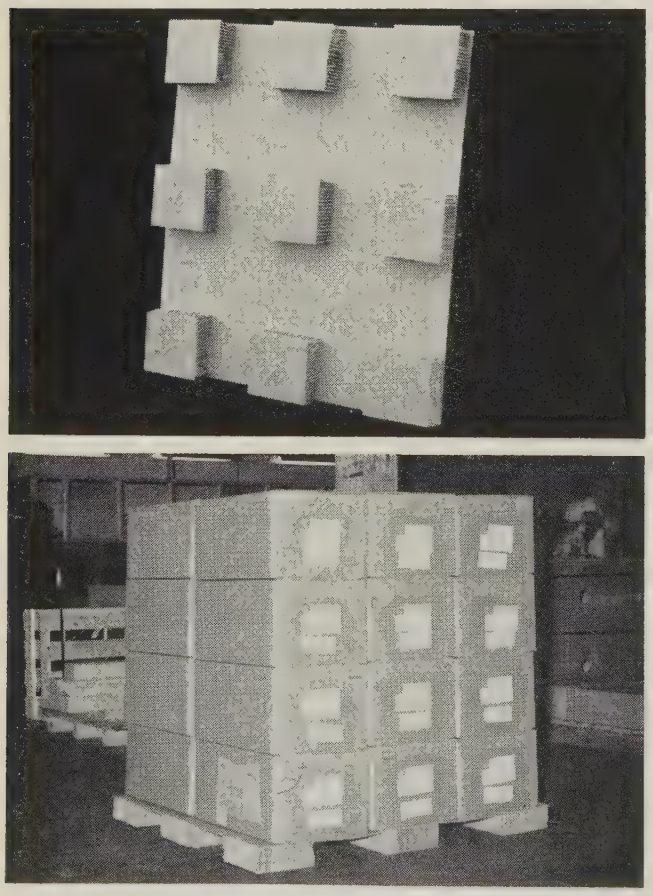

Fig. 6

Table III. Correlation of Wet Strength to Resin Content

(All samples 99-lb. MF kraft, $^3/_4$-in. cell)

Phenolic resin, %	*Compressive strength lb./sq. in. Dry*	*Wet*
0	26	0
11	62	23
18	86	50

resin in the honeycomb seriously reduces the great economic advantage of the all paper pallet. Therefore, less expensive means for achieving the same result were investigated. Two principal approaches appeared particularly inviting: adulteration of the phenolic resin with an extender that would not substantially reduce its effectiveness; and the substitution of low-cost bituminous materials for the synthetic resin.

Both approaches showed some merit as indicated by Table IV. The adulteration of the phenolic with equal

Table IV. Comparison of Equivalent Quantities of Resinous Impregnates

Basis weight, lb.	*Paper stock*	*Cell size, in.*	*Resin type*	*Resin content, %*	*Compressive strength Dry*	*Wet*	*Flexural strength W*	*L*
60	MF kraft	1/2	Phenolic	17	56	33	29	60
60	MF kraft	1/2	P-I[a]	17	53	29	27	65
60	Gumming	1/2	Phenolic	17	66	40	29	63
60	Gumming	1/2	P-I[a]	17	58	32	31	70
80	MF kraft	1/2	Phenolic	18	92	40	55	75
80	MF kraft	1/2	Pitch	..	175	36	..	..
80	MF kraft	1	Phenolic	18	30	..	12	22
80	MF kraft	1	Pitch	..	63	..	..	..

[a] Mixture of equal parts phenolic resin and indulin.

parts of indulin (8¢ per lb.) was particularly promising. However, regardless of their low cost, the bituminous materials were found to be either unsatisfactory or uneconomical. Unsatisfactoriness was due to extremely difficult in-plant processing and the fact that even high softening point pitches were found to creep under heavy load at summer temperatures. The lack of economy resulted from the fact that it was almost impossible to control the weight of tar or pitch applied to the expanded honeycomb, with the result that the quantities used were from 5 to 10 times those consumed when phenolics were utilized.

Other applications of paper honeycomb in addition to shipping pallets include its use in interior packaging to cushion fragile items such as instruments, fine furniture, and, in our plant, transparent flanged spools of tear tape; its use by the Department of Defense as a cushioning material for air drop deliveries; and its use in the construction

Fig. 7

field to produce panel doors, table tops, and wall partitions. In the latter regard, you may have heard of the homes constructed in 1946 in Marion, Va., entirely from aluminum faced paper honeycomb, depicted in Fig. 7. These homes are still in perfect condition today, although the construction is so inexpensive as compared to traditional methods as to suggest that any structure made therefrom would be only temporary in nature.

Presented at the Thirteenth Plastics Paper Conference of the Technical Association of the Pulp and Paper Industry, Springfield, Mass., Oct. 20–22, 1958.

Features of a Semiautomatic Paper Reshipping Warehouse

R. T. FISHER

Recently to provide needed space and to improve our service, we contracted for construction of a one-half million square foot warehouse in Portland. In planning this new property, we concluded early that we must stress automation as well as mechanization of materials handling if we were to gain significant improvement of our operating methods, cost, and capacity.

The result of this, along with more conventional equipment, is a 6000-ft. conveyor that is unique in its combination of great strength, gentle action, and functional and directional flexibility. To the best of our knowledge, this will be the first application of its kind with its combination of characteristics.

This single system will assist us in three functions: sorting of receipts, product movement, and assembly of shipments.

As a public warehouse and transit station between land and water common carriers, handling among other products, industrial and consumer papers, our basic responsibility is fast and accurate service. We must handle any incoming mixed cargo, sort and store it, then move it out promptly in any combination as required.

The products we handle normally are delivered by barge as unstrapped loads on pallets and shipped out by rail or truck. A smaller amount goes the opposite way. We handle an average of 1300 tons per day, about 1500 pallet loads, each weighing from 800 to 6000 lb. On peak days we have moved 2200 pallet loads. Cargo now is moved over manually controlled marine elevators and through the warehouse by fork trucks and trailers over distances as much as 1000 ft. Several dispatchers are required to direct the flow.

With present facilities, our operation has a volume limit of about 1200 pallet loads per shift from the barges with our regular crews. Any excess requires an extra shift or overtime

BASIC DESIGN OF NEW WAREHOUSE

Our operation required a building of at least 550,000 sq. ft., to our knowledge the largest of its type in the West. To attain low initial cost, we designed the warehouse as a single story unit of timber columns and parallel chord trusses supporting a flat plywood and asphalt roof (Fig. 1). To avoid costly piling, the entire structure rests 200 ft. back from the harbor line on concrete spread footings in sand fill. Except for concrete loading docks and the conveyor runways, the entire floor will be 6-in. thick asphaltic concrete over 12 in. of crushed rock. We estimate this floor will be less than three fourths of the initial and maintenance cost of a similar concrete floor.

A minimum of 24 ft. overhead clearance is provided throughout, which we intend to utilize fully with high lift fork trucks. Fluorescent lighting will furnish no less than 25 ft.-candles for operation areas and 15-ft. candles for storage.

R. T. Fisher, Industrial Engineer, Waterway Terminals Co., Portland, Ore.

All rail and truck loading docks are obstruction free with the nearest columns back 15 ft. from the edge. Both types of loading docks are completely covered with roof overhang or canopies for weather-free operation. There is space for simultaneous handling of 35 rail cars and 46 motor trucks.

The 1280-ft. barge dock along the harbor line rests on treated timber piling. It is completely covered and walled and is connected to the warehouse with covered causeways. Seven barges can be worked at once with reserve moorage for an eighth.

DEVELOPMENT OF CONVEYOR

In analyzing equipment possibilities to attain maximum capacity of the new warehouse, a conveyor looked most desirable. However, it was apparent that significant economy would be attained only if the conveyor system would do these things:

1. Automatically carry and distribute loads directly from any barge position to any one of six preliminary segregation zones in the warehouse with random rather than sequential access to the zones.
2. Accumulate loads to a useful limit in these zones without an operator's immediate presence.
3. Require only one man to direct the segregation dispatching.
4. Do all these same things in a reverse flow to the barges.

With these accomplished, fork trucks could work within the limited distance for which they are efficient, about a 300-ft. round trip.

Unfortunately, a ready conveyor design did not exist to cope with our heavy unstable loads. After over a year's research with manufacturers of nearly every type of conveyor, we decided to adapt a subfloor tow line that pulled captive carts. It was mechanically simple and offered a stable continuous bearing surface for the load between any two points on the line which minimize damage.

Standard designs of this equipment did not permit switching and accumulation, but with study we learned how this could be done.

The biggest problem was how to transfer a load from the hoist to the cart and back. We ran the gamut of weird ideas and finally conceived the simple one of letting the cart go right on the hoist and down to take the emplacement of the load. With this solved we let a contract with Mechanical Handling Systems of Detroit, Mich. to design and install the system for operation by January, 1959.

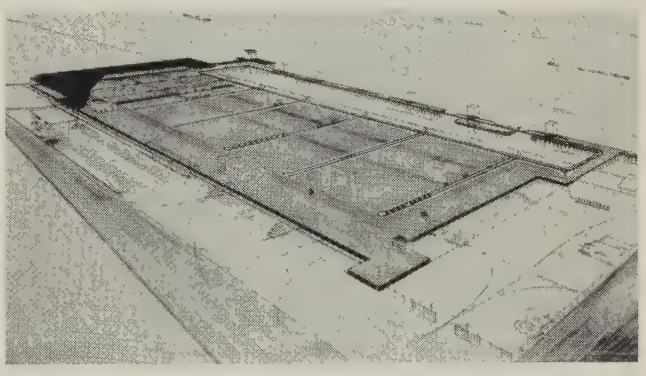

Fig. 1. Cutaway perspective view of 600,000-sq. ft. warehouse and covered dock

Conveyor loop and spur paths shown as heavy flow line. Six ghost line towers along dock show automatic pallet hoists connecting conveyor to fluctuating barge levels. Higher tower in background is heavy capacity marine elevator. Rail spurs and loading docks serve left end, left interior, and front. Truck loading docks in foreground. Part of the 300 captive towcarts that serve on the conveyor are shown in typical work positions.

DETAIL OF OPERATION

Figure 2 shows a simplified view of the total system.

At the top of the drawing is the dock, at which seven barges can be moored at one time. Six of them feed directly to the conveyor system through the automatic hoists. The main conveyor loop, approximately 2700 ft. in circumference, runs clockwise past the six lifts along the dock into and through the 1300-ft. warehouse and back. Extending off the main conveyor toward the bottom of the drawing are the six warehouse accumulator spurs, each about 325 ft. long. Dark rectangles marked S or AS adjacent to the spurs are the manual and automatic stops behind which the carts halt and accumulate for loading.

Three hundred heavy duty carts will travel on the line (Figs. 3 and 4).

After delivering a fork truck and driver to the barge, the pallet lift is switched to "automatic" and starts its cycle by rising to dock level so an empty cart can move on from the feeder line. The pallet lift then descends about 30 ft. to barge level where the barge driver places a load on the cart which will be close enough to the front edge of the pallet lift so he dosen't have to drive his fork truck on the floor of the lift. After the driver has backed sufficiently so his forks are clear, the lift ascends to dock level where the loaded cart discharges to the take-away accumulating line and another empty cart simultaneously moves onto the lift from the feeder line. All action is automatic.

These lines feeding carts to or from the pallet lift act to smooth out time variations in the rate of delivery of loads from the barge to the loops. If the driver matches the lift cycle, each one will deliver a load once every 40 secs.

Loaded carts waiting on the take-away accumulator line between the pallet lift and the main loop automatically progress to the main loop as an empty drive dog approaches. The loop tows the carts on 12-ft. centers at 120 f.p.m. past the dispatcher. Here, a signal is put in the cart which will cause it to deflect at the proper switch. The dispatcher sets the signal in the cart by remote means, operating controls mounted on a console.

At the head of each lateral is an adjustable counter which can be set to accept any number of carts up to the capacity of the spur. A cart entering the lateral progresses to the end where the controllable stop disengages the cart's pin from the tow chain and brings it to a cushioned halt. Subsequent carts accumulate behind, up to the limit set in the entry counter. When the limit is reached, the entry switch will accept no more until a cart is released back to the loop.

The spacing of the laterals is designed to give good primary distribution of the different types of commodities brought in. The four laterals on the right serve the stock item area in the warehouse. The two on the left are close to the inner rail well so through shipments, which comprise half our tonnage, can be loaded from the carts directly to rail cars from either side. The return leg on the extreme left also serves as the primary loading line for materials sent back to the barges. This material may have come from barges originally, or from the nearby receiving docks.

When the lift driver working a zone removes loads he can, without dismounting, release a single cart or a group which will move to the other side of the spur and halt if the stop there is activated. Here the balance of unloading takes place and the carts are released in the same manner to return to the loop. A final automatic stop holds the carts for proper phasing into an empty drive dog on the loop. As one leaves, the counter deducts it so another can enter the lateral.

As carts leave any lateral to enter the main loop, the signal which sent it to that lateral is automatically cancelled so

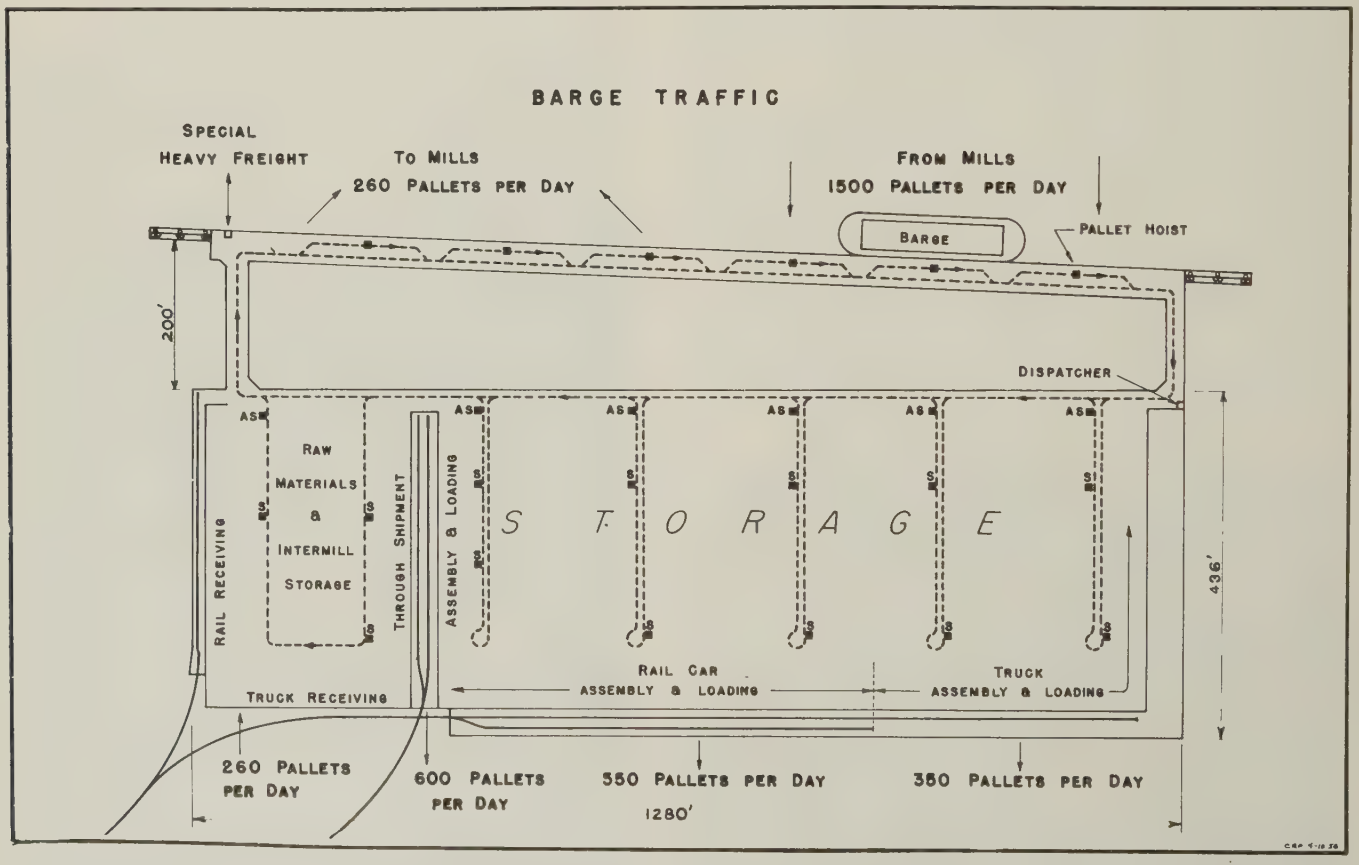

Fig. 2. General flow and layout diagram of conveyor and warehouse showing 1300 tons average daily traffic sorted and interchanged between barge, rail and truck lines

Each pallet represents a load from 800 to 6000 lb. There is space for handling 35 rail cars, 46 motor trucks, and 7 barges simultaneously.

the cart will enter the nearest pallet lift feeder line which has space for it. This cancelling device is controllable so a cart can be released from a lateral with a set signal in it to go only to a specific point. This permits loads from any point in the warehouse to be directed to any one lift, or for that matter, back to any spur in the warehouse. Thus the system is fully capable of movement and segregation between 12 zones with only one primary dispatcher.

Its flexibility also permits use of the conveyor for order assembly. We can send loads from any remote stock location to a lateral near a carrier's loading point with the fork trucks moving only short distances. Thus we can place our stock, as it comes in, where we have space, with consideration of volume rather than in specifically assigned locations by type. Over 25,000 sq. ft., which formerly we thought would be aisles in a stock layout of assigned locations, many duplicate, will now be used for inventory. Control of placing the stock is under one man, and finding it for order assembly will be vastly simplified.

MECHANICAL FEATURES

Some mechanical features of the system may be of interest. With cart loads in the system up to 6800 lb. and speed of 120 f.p.m., each moving cart can have a maximum of 500 ft. lb. of kinetic energy—a difficult force if it is not cushioned at stops and starts.

To stop one cart behind another, a tow pin lifting device raises the pin free and shock absorbers, built into every cart, go into action as contact is made with the one ahead (Fig. 3).

For easy, cushioned starting of the heavy loads, all tow pins on the carts are spring loaded (Fig. 4).

The dispatch system is flexible and easy to maintain. All its switches and controls are mechanical. Controls and devices at accumulating stations also are mechanical.

The only electronics involve drives in the system which are automatically phased together and are controlled from one point.

Assisting devices in using the conveyor will be provided in the form of a two-way, wired voice communication system covering the warehouse. In addition the dispatcher will have a closed circuit television system so he can monitor blind areas from his seat.

BENEFITS FROM CONVEYOR

What will this system do for us? We think a lot of things:

1. A greatly improved capacity to handle up to 2400 pallet loads per shift from barges will be available.

2. Regardless of cargo mixture, selective spotting of barges at the warehouse will no longer be necessary because stock can be directed from any point to the proper area, by one man, with good location control.

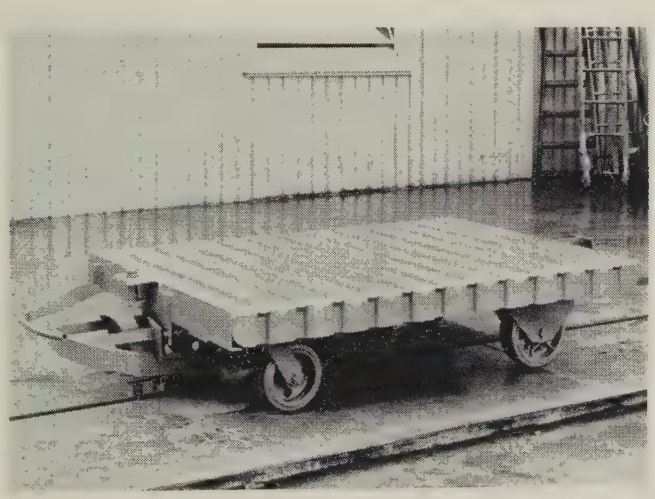

Fig. 3. Pilot model of captive tow cart showing shock bumper and towpin lifting bar

Top is 9-gage pressed steel, fluted for greater strength.

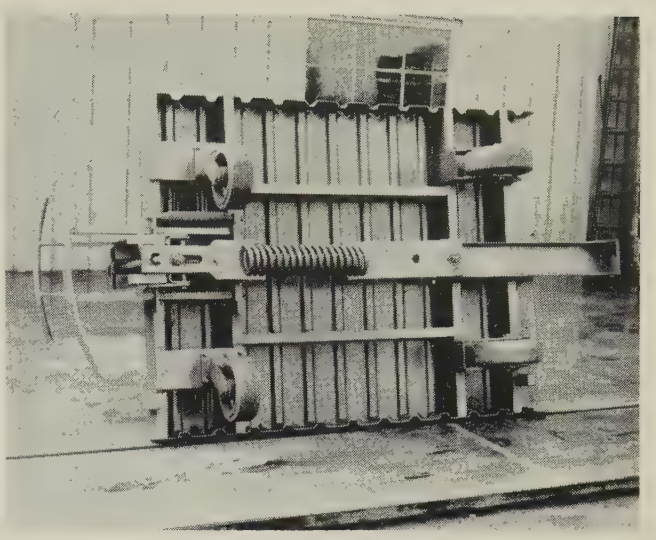

Fig. 4. Under view of cart showing start and stop shock dampers

Signal flags are not installed on the pilot model.

3. Palletized or nonpalletized unit loads or large rolls can be handled equally well.

4. Better utilization of storage space will result because fixed stock locations are not necessary.

5. The conveyor system will facilitate assembly of mixed orders, regardless of the distance between stock and carrier loading point. This also makes the use of the loading docks more flexible for the same reason.

6. Stock turnover will be much better as it will be possible, by means of this conveyor, to ship stock from the back of a line-up without moving fresh stock that may have been placed in front.

7. Less damage to the products will occur, due to reduction of lift truck travel.

8. It will stabilize cost by transferring work from men to machines. Key personnel are stabilized and training of additional men, when volume requires, will be greatly eased because of the restricted zonal operation.

9. A good means is provided to pace productivity without the ramifications of work measurement standards since work can be keyed to the conveyor.

10. Barge utilization will be improved as barges will spend less time being unloaded.

11. Selective loading at the origin will no longer be necessary in order to reduce our sorting problems.

12. New possibilities will exist to apply control counts of cargo with all movement going by one point.

OTHER HANDLING EQUIPMENT

Not all cargo will go over the conveyor system. A portion involving general cargo and very heavy items will be handled by means of a hoist and monorail and a 15-ton capacity semiautomatic marine elevator where the seventh barge will be moored. Other devices also facilitate operations in the warehouse. The truck loading dock will be equipped with 22 hydraulic self-leveling loading ramps. A feature of these ramps is they have no permanent projection beyond the dock edge to be damaged by backing trucks. A pneumatic tube will be used to transmit a steady flow of orders and bills.

Presented at the Thirteenth Engineering Conference of the Technical Association of the Pulp and Paper Industry, Portland, Ore., July 28–Aug. 1, 1958.

Project contractors: The general contractor is Reimers and Jolivette, truss and roof construction is by Ritter Roof Structures, Inc.; and the dock by General Construction Co., all of Portland. Colby Steel and Manufacturing Co. of Seattle, Wash., is building the heavy marine elevator and the six pallet hoists for the conveyor. The conveyor contractor is Mechanical Handling Systems, Inc. of Detroit, Mich.

Nylon 6 as an Extrusion Coating Resin

O. J. WOLFF

As you all know, the use of extrusion coated papers for packaging and related applications is a large and rapidly growing industry. New uses are being developed almost daily for these materials. However, at the present time there are many limitations in their use imposed by inherent deficiencies in properties of the coating resins available for commercial use. Polyamides are currently receiving intensive study to determine their utility in applications for which other materials are not suited. In extrusion coating processes, polycaprolactam (Nylon 6) types appear to have achieved the best results to date.

Nylon 6 has been found to be particularly adaptable for extrusion operations. Generally speaking, polyethylene equipment with minor modifications can be used for direct extrusion coating of paper and other web materials. Coatings having excellent clarity and gloss can be obtained with high yields. One-mil coatings are equivalent to 17.8 lb. of resin per ream (3000 sq. ft.) Little difficulty is experienced in obtaining coatings free of pin holes. Film-to-paper adhesion obtainable is believed to be adequate for virtually all types of fabricating procedures used to form industrial containers and special packages. Heat sealing, using one of several types of machines, has been demonstrated. Effective adhesives are available for other methods of joining or closure.

The properties of polyamides are of special interest to converters and manufacturers of industrial containers. Films and coated web materials have high tensile strength, tear strength, burst strength, and excellent flex endurance properties. Typical physical properties of commonly used paper web materials coated with Nylon 6 type extrusion resin are shown in Table I.

For these tests, 25-lb. bleached kraft, 30-lb. and 50-lb. brown kraft papers were used. Nylon films approximately 1 mil (18 lb. per ream) and $1^1/_2$ mil (25 lb. per ream) were coated and tested under standard ASTM methods. A 20-mil die opening was used during extrusion so that a degree of orientation was obtained in the machine direction of the applied coating.

Basic properties of unsupported film have been tabulated in Table II to indicate effects obtainable using other web materials.

Equally important to end-use applications are the vapor transmission and permeability properties of the film component of extrusion coated materials. Nylon films have relatively high moisture transmission rates, especially at elevated temperatures and high relative humidity environment. Transmission rates obtained on samples of extrusion coated kraft paper and film are shown in Table III.

O. J. Wolff, National Aniline Div., Allied Chemical Corp., Hopewell, Va.

Table II. Properties of Nylon 6 Flat Film

Property	Units	ASTM test method	Machine direction	Transverse direction
Tensile strength	P.s.i.	D 882–56 T	8500	7500
Yield point	P.s.i.	(2 in./mm.)	3500	3400
Elongation	%		230	250
Tear strength				
Elmendorf	g/mil.	D 689	90	130
Graves	P.s.i.	D 1004	1000	900
Miscellaneous properties				
Moisture absorption, % (at 50% R.H.)			2.5	
Moisture absorption, % (maximum)			8.5	
Specific gravity			1.13	
Yield, sq. in./lb./mil			24,000	
Flammability			Self extinguishing	
Continuous service temperatures °F			−100 to +150	
Taste and odor			None	
Printability			Excellent	

Table III. Moisture Vapor Transmission Nylon 6 Film and Coated Kraft Paper

	ASTM method	Temp., °F.	Relative humidity, %	Moisture transmission[a]
Coated kraft (1 mil coating)	E 96–53 T	73	50	15
Film (1-mil)	E 96-53 T	73	50	21
		100	90	360

[a] Grams H_2O/sq. m./day.

In these tests, transmission rates for coated kraft were roughly 25% lower than unsupported film. Differences in degree of orientation may account for this change. Preliminary data indicate that bilateral orientation of film further reduces moisture transmission rates. Since permeability rates through plastic films vary exponentially with temperature (*1*), it can be assumed that at subnormal temperatures, such as refrigerated conditions, considerably lower rates will apply.

Permeability of nylon film to various gases, however, is relatively low. Rates determined at essentially room temperature with 10 p.s.i. pressure differential across the film are shown in Table IV.

These tests were made using the method of Todd as modified by Brubaker and Kammermeyer in studies sponsored by the Atomic Energy Commission (*1*). The permeability constant P is defined as: the number of standard cubic centimeters (0°C. and 1 atm.) passing through 1 sq. cm. of film (1 cm. thick) per sec. per cm. of mercury partial pressure difference across the film. Their work, at that time, was

Table I. Properties of Extrusion Coated Kraft Paper

Property	Units	Direction	ASTM test method	25-lb. bleached kraft			30-lb. unbleached kraft			50-lb. unbleached kraft		
				Paper	Coating 18 lb.	Coating 25 lb.	Paper	Coating 18 lb.	Coating 25 lb.	Paper	Coating 18 lb.	Coating 25 lb
Yield strength (Scott)	Lb./in.	Machine	D 882 A	20.8	28.3	28.6	16.8	23.3	25.6	25.8	34.3	39.5
		Transverse		13.8	22.1	19.5	10.2	16.6	17.6	25.8	33.1	33.6
Yield strength (Instron)	Lb./in.	Machine	B	22.4	25.8	28.8	18.8	23.9	25.5	28.7	33.8	39.5
		Transverse		14.0	18.7	22.1	11.7	17.7	17.9	25.1	33.0	33.9
Tensile modulus (Instron)	Lb./in.	Machine	D 882	1745	2430	2385	1800	2390	2160	2320	3120	3100
		Transverse	B	1005	1665	1460	910	1340	1260	1480	2170	2065
Tear strength (Elmendorf)	G./4 sheets	Machine	D 689	26	116	144	33	124	136	142	248	252
		Transverse		32	156	188	39	152	156	111	196	248
Bursting strength (Mullen)	P.s.i.	Dry	D 774	21	25	28	20	23	24	37	50	49
		Wet		4.1	33	36	2.7	27	29	4.0	52	57
Fold endurance (M.I.T. tester—1 kg. load)	Cycles	Paper[a]	D 643	418	680	941	250	400	435	1800	3000	4800
		Film		..	>25,000		..	>25,000		...	>25,000	

[a] Transverse (weak) direction.
Coating weights: lb./ream (3000 sq ft).
Coating resin: Plaskon Nylon 8205.

Table IV. Permeability of Nylon 6 Film
At 23°C. and 10 p.s.i.g. ΔP

Type of gas	*Permeability*[a]
Nitrogen	0.001–0.003
Oxygen	0.003–0.005
Carbon dioxide	0.008–0.020

[a] cc.-cm./sec.-sq. cm.-cm Hg. × 10^9.

limited to testing of polyethylene, cellulose acetate, and vinyl films. However, independent tests in our laboratories and data subsequently reported in the literature (*2*) fall within the range of values shown.

The most interesting property of Nylon 6 films and coated papers is its superior resistance to permeability and degradation when exposed to organic compounds. A selected group of tests representing a variety of potential packaging applications were run to check performance that could be expected of this film. A few results are shown in Table V.

These tests were run under conditions of relative humidity and temperature expected in unconditioned storage areas. Relative humidity varied from 60 to 90% and temperatures from 50 to 85°F.

Odor retention of the materials in these packages was excellent and it is assumed that changes in moisture content account for the small changes in weight occurring in these samples. These tests, however, suggested further investigations to determine the effects of organic chemicals and petroleum products on Nylon 6 film. Excellent resistance to kerosene, motor oil, and paradichlorobenzene (moth repellent) was demonstrated.

Oil resistance tests were conducted by placing 1-mil film and 30-lb. kraft paper over a small inverted pot. This assembly was placed in an oven at 60°C. and the time required for the oil to penetrate the film and spot the kraft paper was recorded. A comparison of results obtained with Nylon 6, polypropylene, and several samples of polyethylene is shown in Table VI.

Other tests now in progress show Nylon 6 film to be virtually unattacked by kerosene and paradichlorobenzene. In each type of test, polyethylene failed completely in relatively short periods of contact. This testing program has been expanded to obtain data on other petroleum oils and greases, common chemicals, and various food products.

The general properties of Nylon 6 can be summarized as follows:

1. Strength Properties
   a. High tensile strength
   b. High bursting strength
   c. Good tear strength
   d. Excellent fold and flex endurance
   e. Superior abrasion resistance
   f. High heat resistance
2. Chemical Resistance Properties
   a. Superior oil and grease resistance
   b. Superior barrier to organic vapors
   c. Superior resistance to common chemicals
3. Processing and Product Characteristics
   a. Easily extrudable
   b. Good adhesion to web materials
   c. Uniform, pin-hole free coatings obtainable
   d. Excellent clarity and gloss
   e. Heat sealable

Table V. Weight Changes of Materials Packaged in Nylon 6 Film

Material	*% Change after 30 days, %*
Motor oil	0.0
Kerosene	0.0
p-dichlorobenzene	+0.1
Cake mix	+0.3
Pancake mix	−0.8
Coffee	+1.0
Cocoa	+1.5
Dog biscuits	−0.8

Table VI. Oil Resistance of Plastic Films

Material	*Time to failure, hr.*
Linear polyethylene	
Sample A	14–84
Sample B	74–84
Sample C	230
Polypropylene	340
Nylon 6	>1200[a]

[a] Test to failure incomplete (30 days = 720 hr.).

A review of these properties suggests many new uses for film and extrusion coated products. It is expected that these materials will soon be applied to greatly expand the potentials available in the industrial container and packaging fields.

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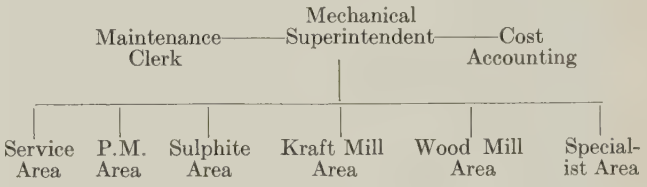
Presented at the Thirteenth Plastics-Paper Conference of the Technical Association of the Pulp and Paper Industry, Springfield, Mass., Oct. 20–22, 1958.

Maintenance Planning, Scheduling, and Cost Reports

A. M. CADY

I plan to confine my remarks to the actual mechanical maintenance department of our mill, because that is the area which I feel I am most qualified to talk about. We are talking about 300 men in our maintenance department. We have divided the mill into maintenance areas, each of which is under the direction of a supervisor who reports directly to the maintenance superintendent. In order to make this a little more clear, the organization is as follows:



For example: The paper machine area supervisor is responsible for all the maintenance work carried on in the area of paper machines, beater room, and finishing rooms. He makes the contact with the department superintendents as to the work to be done in his department.

The same with the sulphite, kraft mill, and wood mill area supervisors. The specialist area is a group of men under a supervisor who are specialists in their work such as automotive mechanics, roll and cylinder wire covering, elevator maintenance, etc.

The maintenance service area is a group of men under the supervision of the assistant superintendent, which in this case is the author. This group includes general maintenance crews, machine shops, pipe shops, masons, painters, welders, etc. They are the services for the various area crews as outlined on the board. If a certain area maintenance supervisor has more work than he can accomplish in the time allotted, he will call on help from one of the construction crews, pipe shop, labor crew, etc. The rigger crew is a group of men who work in all departments of the mill. They make

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all of the large paper machine roll changes, as well as do the various heavy rigging jobs throughout the mill. They may be changing a small press roll one time and the next day they may be changing a Yankee drier on one of the paper machines. Each maintenance area supervisor is responsible for all the maintenance work done in his area. Any work done by any other crew or service in his area becomes his responsibility. Each maintenance area supervisor makes the contacts with the department head of the area that he services and reports directly to the maintenance superintendent.

Before getting into the actual planning or scheduling of maintenance work, let us take a few minutes to find out just where the requests for work originate.

Prior to 1925, the maintenance work was done more or less by verbal work orders or an occasional note or memo from some supervisor or members of management. In 1925 a progressive step was made, we thought, when the work order system was inaugurated. This was an improvement in that it provides a record of the work requests and gives us a chance to work up some costs if desired.

We have since made some improvements to our work order system, which we feel are worth while. All work orders are sent to the maintenance control department. This group expedites the requests for work which are made to this department in the form of work orders signed by department superintendent or one of his authorized subordinates. The work orders are addressed to the maintenance clerk and include the following:

The date written, required completion date, charge account number, and a reasonably complete description of the work. Work orders are made in triplicate, the department superintendent or whoever wrote the order retaining one copy, the remaining two copies being forwarded to the maintenance clerk.

Work orders are processed as rapidly as possible consistent with obtaining the necessary information, approval, scheduling, and recording.

Shop orders are written covering the type of work, as indicated by specific requests, comes under the head of general maintenance, and receives attention depending on the importance of the work—whether it is classified as normal maintenance or emergency maintenance.

We might then say that these work orders are originated by a department head for some maintenance jobs, small construction, or change in equipment that he might want to have done.

They may originate from capital additions, and replacements considered necessary by management.

Various maintenance people, including mechanical inspectors, sometimes request or suggest changes or repairs that should be made.

Our safety suggestion system and improvement suggestion system are also sources of work orders.

The maintenance work in our mill can be divided into three groups: (1) routine maintenance work, (2) shutdown maintenance work, and (3) major replacements and additions.

The routine maintenance work is that "day to day" work that is carried on daily; the smaller jobs that can be done any time or that can be done with the equipment in operation or producing. These may be the overhauling of units of equipment or the repairing of worn out parts that have been removed or changed. This should be done at the earliest opportunity so they will be available and mechanically fit for use when needed. Such repairs require the minimum of planning or scheduling for their execution. However, the maintenance supervisor should plan far enough ahead to have the necessary spare parts on hand when needed. A maintenance supervisor must have a crew of the correct size that they will always have a backlog of work. They should never catch up or be in a position to say, "I have nothing for the men to do." It is always better to have too few than too many mechanics in a maintenance crew. Each departmental or area crew can always get additional help from the service area crews if necessary.

In performing these routine jobs we use records of previous similar jobs that have been done at some prior time. We have found that writing or outlining some of the more difficult jobs helps a junior grade mechanic in his work. The more simple jobs depend on the experience and training of the men in the crew. The supervisor does the planning and supervision until the men are able to handle the job themselves.

We are training our men in the practical skills of their respective jobs and we are contemplating practical skills testing, which we feel will give us more capable and finished mechanics.

In our mill we have only three total mill shutdowns per year. These come on the 4th of July, Labor Day, and Christmas. During these holiday periods, we try to closely restrict any maintenance or construction work. From this you can see that most all of our maintenance work has to be scheduled. Let us take a few minutes to talk about maintenance on the paper machines. Our paper machines run on a 7-day operation, except in recent months when they have been somewhat curtailed.

Every morning, from Monday through Friday, a meeting is held in the paper machine department office. This meeting is attended by the general superintendent of paper production, one or two members of management, paper machine supervisors, maintenance superintendent, assistant maintenance superintendent, pipe fitter supervisor, superintendent of steam and electrical power, paper machine millwright foremen, and others directly interested or connected with paper machine maintenance. Each paper machine running schedule is discussed at this meeting. Also any important repairs or changes that are to be made. Anyone familiar with a paper mill knows that paper machines have to change wires, felts, calender stacks, or grind rolls, or washup for grade changes at various intervals. Each paper machine is discussed as to shutdown for any of the above reasons.

Our paper machine department is divided into two groups—the wrapping machine group and the tissue machine group. Each group has seven paper machines. The jobs or work on the various paper machines have to be scheduled so that they will not conflict with each other. We have only so many electricians, pipefitters, millwrights, etc., and they cannot be on several machines at the same time. We try to stagger the shutdowns so it will be possible to get all the necessary work done in the allotted time that the machine is to be down. If a machine is to put on a wire or a felt on a certain day and is expected to be down for 2 or 3 hr., the maintenance people concerned schedule some of their work to be done at this same time. If there are no major or urgent large maintenance jobs to be done on this certain machine, the length of the jobs done is determined by the time the machine is scheduled down for the clothing repairs or replacements.

As mentioned before, each crew has a backlog of shutdown work to be done when the machine is down. Each supervisor plans the work that his crew is to do, with emphasis put on the length of time the machine is scheduled down. He takes into consideration the longer jobs that require some other craft, such as machine shop, pipe fitters, etc. These are the jobs that should be started first in order to finish them in the allotted time the machine is to be down. This paper machine meeting helps to do this because those concerned are present. The prime considerations are the longer jobs. They are the ones that are concentrated on. By taking advantage of these operational shutdowns we are able to keep the number of maintenance shutdowns to a minimum. It is only in rare occasions that we are forced to ask for a maintenance shutdown to do some maintenance work in the paper mill.

If there are major repairs to be done on a paper machine, the longest job is taken into consideration as the prime factor. If the paper machine millwrights have a job that is to take 8 hr., the other maintenance people and the paper machine supervisor plan their work accordingly, so the work can be completed in the time estimated. This does not always work, but in most instances it comes fairly close. We sometimes are not able to follow our plan to the letter but a sincere effort is made to do so. These longer maintenance shutdowns are coordinated with the paper machine people so they can take advantage of the time down for clothing repairs or washups, etc. Production lost on a paper machine running 7 days a week cannot be made up—"it is water over the dam."

Each Tuesday we have a planning meeting with the maintenance supervision of the various departments of the mill. At this session we are able to develop an over-all picture of the entire mill. We go over what is planned for the week ahead involving the operational shutdowns that are scheduled. There are times when a shutdown in one department may effect another department or make it possible to do some other maintenance work in that department. It is by this method that we are able to plan together what work is to be done and when.

Let's talk a little about major construction jobs. They take a little more planning. Whoever is in charge of the job goes over the job and prints with the maintenance foremen and they outline in detail just what work has to be done by each craft or department involved. This includes the preliminary work and the actual installation or shutdown work. When this outline is completed, a meeting is called with everyone concerned in the job present.

All phases of the job are discussed in detail. It is then determined just how long a shutdown is necessary to complete the job. A date is also set as to when the preliminary work has been completed and you are ready to schedule the job.

Let's take a few minutes to talk about the scheduling for our maintenance work.

The routine maintenance jobs do not require a lot of scheduling. The supervisor of the crew reviews the backlog or work and keeps a list of the most urgent or priority jobs. He coordinates this work with the other crews where necessary. It is very important to keep enough of this routine work ahead of the men at all times. And what is more important is that they know how and what to do on a particular job.

The scheduling of work to be done during operation shutdowns requires a little more thought.

First, we attempt to get all the maintenance possible completed or done during the operating shutdown.

We always try to advise the operating people if additional time is needed for a particular job.

The various meetings with the operating departments where we discuss the operating schedules assist us greatly in the scheduling of our work. It is important that the supervisor or the work knows pretty well how long each job will take. This also helps him in planning and scheduling the longest jobs to be started first or immediately when the equipment goes down.

On the large maintenance jobs a time or length of shutdown is determined by the maintenance supervisor in charge prior to the shutdown. The operating personnel are advised accordingly. Everyone concerned is working for the same goal—to minimize the scheduled down time of the machine or equipment.

The priority of the normal routine maintenance jobs is determined by the maintenance supervisor from experience. He should know what work is the most important and which can be held off for a later date. The priority of the major or principal jobs is left to the department operating supervisor. He is the customer and he knows what he wants first. We are the sellers or the service department to try to give him what he wants. We don't actually make any money in one sense of the word but we do try to maintain the equipment so the production department has a product to sell at minimum cost.

We have one accountant in the maintenance department who checks each time sheet each day that is made out by each maintenance foreman for his particular crew. He adds the sheets and checks for errors in the account or job numbers, etc. He codes the accounts and jobs for the tabulating department.

The time office then puts the proper distribution of premium time and call time on the time sheets for the tabulating department and verifies this time with the employee's time card for the distribution of cost of maintenance and payroll. The following reports are received from the tabulating department:

Weekly report no. 1—All AFE charges by maintenance crews.
All special jobs charges by maintenance crews.
All mill accounts charges by maintenance crews.

Weekly report no. 2—All charges to each work order by each maintenance crew.

Report no. 3—Is a monthly report on all charges made to each job or account and each work order number listed and each maintenance crew that worked on the particular work order, also all maintenance that does not have a work order to support it is listed by crews. Records are kept for 5 years.

We have our daily overtime and call time reports which show the actual hours worked by each man, in what department, and sometimes the reason for the extra work.

We have a monthly labor and material charge report for each department in the mill.

On the larger jobs we charge maintenance labor and material directly to the job and report the costs in total.

On the smaller jobs we don't normally review individual job costs except when jobs appear out of line. The IBM system permits us to go back and make labor segregations on abnormal work order jobs at any time.

These reports are made available to all concerned and we feel that this gives the crew supervisor a better look at what is being spent and what jobs are costing.

The large maintenance jobs are followed very closely day by day in order to try to stay inside the estimated costs for that particular job. Of course, there are times when we may have to ask for more money to complete an estimated job. When this is necessary we have to know the reason "why?" and explain same before we get the supplemental OK'd. All major jobs are estimated by the engineering department with the assistance of maintenance personnel and their experience.

In conclusion, let's briefly summarize. The principal objective of the supervisors in the maintenance department is to maintain equipment in good repair and avoid interruption of operating time and to do it at the lowest practical cost by an organization which attempts to give people definite but limited responsibilities for planning, scheduling, and cost control of maintenance work.

1. The planning of maintenance work is tied to operating schedules to minimize the loss of production.

2. We depend on the experience and ability of our foreman and leadmen for planning routine jobs with a minimum of written procedures.

3. We concentrate planning efforts of foreman and supervisors on the large unusual and the "first time through" jobs.

As for scheduling:

1. Shutdown work is tied to operating schedules.

2. In routine work a backlog is necessary. Attempt to do the most urgent jobs first.

3. Departmental crews are kept small enought to have a backlog of work at all times. Departmental crews may be supplemented from central maintenance crew at times when necessary.

Cost Control:

1. We have weekly and monthly cost summaries by departments and by large jobs.

2. We do not put out cost reports on every work order, but their cost may be found from IBM if any one of them is suspected to be out of line.

The author is very happy to have had the opportunity to take part in this session today and to describe in a few words the maintenance planning, scheduling, and cost accounting at the Crown Zellerbach Camas mill.

Presented at the Thirteenth Engineering Conference of the Technical Association of the Pulp and Paper Industry, Portland, Ore., July 28–Aug. 1, 1958.

Better Quality and Reduced Costs Through Better Testing Methods for Paperboard

L. K. BURNETT and R. L. LEWIS

During the past several years, we have all seen our customers' quality requirements raised to higher levels, manufacturing costs raised to all-time highs, and competition become keener day by day. The future holds no relief from this upward trend.

As technical men in the paperboard industry, we have been vitally concerned with programs designed to improve quality and reduce costs. We believe that improved methods for testing paperboard can help in both areas.

The manual sampling and testing methods we use to control the production of our multicylinder paperboard machines are too incomplete, too slow, too inaccurate, and too expensive. The methods we use do not provide the assurance we must have that we are producing the best quality the process is capable of at the lowest cost.

A typical board mill runs physical tests on a set of square foot samples taken each half hour across the machine, front, middle, and back. If we assume a 120-in. machine running 0.022 board at 250 f.p.m., this means we are basing our test information on a sample of about 3 one thousandths of 1% of the production. About the best we can hope for is that we have a reasonable average over a long run, but we certainly have inadequate data to show variation through the run. In addition, our destructive testing techniques reduce the amount of saleable board by several times the sample amount.

Our board testers are honest and objective, however are human and as such, subject to human errors in sampling and testing. Several of you have experienced the uneasy feeling that the test result might have been influenced by their desire and the operating personnel's desire for the right result.

Too much time and labor is required to obtain the test results. A mill operation we believe to be typical assigns about 15% of their direct labor costs to beater room and paper machine inspection. In most cases, test results are not available for action by the operating crew until 15 to 20 min. after the sample is taken. If we assume a 6-ton per hr. production rate up to 2 tons of board would be involved before action could be taken to correct any deficiencies and another 2 tons of board before the change reaches the end of the machine.

Many of us have already taken some steps in the direction of continuous testing; however, we believe we should accelerate our efforts. We should follow the example set by other process industries and by other parts of our own industry by devoting more attention to the application of continuous nondestructive automatic recording of test data and automatic control where possible based on this information.

As an example, one of the major automobile manufacturers in its newest engine plant has a fully automated inspection process as well as fully automated machining operations. Gages have been installed throughout the production line to check each part automatically on its way from one machine to the next. On the engine block line, for example, gages have been installed that automatically check the cylinder bore and the width of bearing surfaces. On finding an out-of-tolerance part, the inspection equipment either signals trouble or kicks the defective part out of the line.

The modern oil refineries would be unable to make the variety of product they do were it not for completely automatic measurement and control of their process variables.

The strip mills of the steel industry are very similar to our operations. They too are concerned with the manufacture of a wide web of material uniform in thickness, density, smoothness, and strength. It is quite enlightening to realize that an entire hot strip mill from ingot to finished coil of steel sheet can be operated and controlled at several thousand feet per minute by one man in a central control booth.

Let's visualize where we might improve our control with lower costs and better, more uniform quality the result.

Consistency regulation on all our stocks insure better uniformity in such things as stock preparation, sizing, and coloring. There are many proved regulators available. Direct savings in power, better cleaning efficiency, top liner pointage control, sizing efficiency, etc. have been some of the benefits.

Automatic pH controllers are available which not only measure but control the addition of alum. Many mills have realized substantial savings not only in chemicals but have benefited due to less corrosion on equipment as well as improved uniformity. How many pounds of expensive pigment or bleached pulp would be saved if we had an automatic brightness meter in the topliner stock lines? This type of instrument is already in use monitoring virgin pulp bleach plant operations.

Many of us control strength development, formation, and ply bonding using some form of freeness test. A freeness test does not always correlate with what happens on the machine; however, we use the test because we lack something better. On a recent mill visit we saw an automatic continuous drainage rate tester which controlled the power input to a tickler jordan. A portion of the stock going through the headbox was by-passed through a miniature cylinder mold. Change in head in the vat was the basis for their control. Perhaps this is an improvement worth further investigation by us. We have seen brochures covering a continuous recording freeness tester that some of you may have seen.

There are several instruments available which are useful for wet end weight control. Certainly we could expect more uniform control with less variation and faster grade changes as some of the benefits. One such piece of equipment uses a beta ray gage either in a stationary position or traversing the sheet. Other instruments are available which either weigh or caliper the wet sheet. Variation from desired control points is recorded continuously and either lights a signal so that a manual change can be made, or adjusts stock gates automatically. As might be expected most mills have found consistency control essential as a first step to prevent wet end weight controls from "hunting" and overcontrolling.

Continuous moisture recording and controlling is a very important must. Uniform moisture content at the proper level affects quality in many areas. Ability to finish the sheet affects smoothness and printability. Strength and bending quality are dependent on proper moisture. We have all seen subsequent converting plant troubles due to lack of uniform moisture control. Much curl, warp, cockle, faulty ink drying, off register printing could be prevented if we had improved moisture control.

L. K. Burnett and R. L. Lewis, Ohio Boxboard Co., Rittman, Ohio.

Many of us have or have tried various drier controls. We are all familiar with the indicating driers, tension types, temperature drop and measurements of resistance or capacitance. Any or all may be satisfactory; however, at least in our mill where we run many different grades and calipers. we have not been entirely satisfied with their performance. We may be asking the impossible; however, in our opinion a foolproof continuous moisture measuring, recording, and controlling instrument for multiply board still needs further development. Basis weight can now be continuously measured and recorded using available instruments such as the beta ray gage. How much better information is available when we compare 3 to 5 thousandths of 1% sampling with a continuously traversing beta ray gage. Caliper can be continuously monitored using available equipment. One such instrument uses a series of rollers which ride the sheet. Caliper variation is reflected by change in inductance of primary and secondary coils mounted on the supporting yoke of the roller.

All of us are aware of the tremendous number of dollars that would be available if we were able to cut down even a small percentage of the weight and caliper variation we now experience. Ability to run narrower tolerances because of continuously available weight and caliper information would soon pay for the instrumentation. Unquestionably better uniformity would be reflected in improved converting plant efficiency plus an increase in board mill efficiency with some real dollar value, in yield per ton of raw material. By collecting test data continuously and automatically, testing manpower could either be decreased or we could increase the frequency of other tests.

We believe that many optical tests such as brightness, gloss, and perhaps color might eventually lend themselves to continuous measurement. We have seen continuous recording gloss meters in use on book paper supercalenders as an example.

In thinking about what we might do to start an industry program, we realize there are complexities that would logically require the efforts of several of our industry technical committees. A theoretical approach would be to set up a joint-correlating committee with representatives who could outline what tests are necessary for quality-production control, and could survey what equipment is now available, outline its features, and evaluate its effectiveness similar to some of the instrumentation studies already available for bench type testing equipment.

It also seems desirable to have some sort of standardization of method and if possible standardize such things as size and shape so that equipment could be fitted properly, not only on the new installations but some of the established mills where space may be a problem.

We visualize some day a traversing multihead search unit scanning the web and continuously feeding information to a cluster of recording charts on a single panel easily accessible to the board machine operator.

What we have outlined may be in some minds an impossible unnecessary Utopia; however, only the future can foretell this. What may seem unnecessary today may turn out to be a must for tomorrow. It is our personal opinion that tomorrow is already here.

If this is true, then self critically, we as paper chemists may be spending too much of our time and effort on bench-type tests. We feel strongly that we should be devoting more of our effort toward working with our operating and engineering people and with the instrument manufacturers to improve the continuous measurement and, where possible, automatic control of our process variables. The result can be expected to improve our quality and reduce our costs.

Presented at the Ninth Testing Conference of the Technical Association of the Pulp and Paper Industry, Savannah, Ga., Sept. 30-Oct. 3, 1959.

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Maintenance Planning and Scheduling at the Longview Fibre Company

V. M. SUTHERLING

THE author has been requested that he discuss the methods and planning that are used at the Longview Fibre Co. to take care of preventative maintenance, routine maintenance jobs, equipment shutdowns and any construction work done by our mechanical crews. Before explaining our system a brief description of the mill will be given so that you can relate it to the work done and facilities provided for doing this work.

We produce 1000 tons per day of kraft board and coarse papers on five fourdrinier and two cylinder machines. About 40% of our production is converted into shipping containers at our box plants in Longview and Seattle, Wash., and at Oakland and Los Angeles, Calif. The balance of our production is made into bags or other converted items at our Longview plant or is sold in the form of paper or paperboard. In addition to 14 digesters we have an 80-ton per day semichemical operation and a groundwood mill. Total employment is about 1600 with 485 in the engineering department. Included in this 485 are 16 design engineers and 330 mechanics and helpers.

Management at our mill is very conscious of operating an efficient organization and of keeping equipment shutdowns at a minimum without uneconomical expenditures. Our system for handling repair work, alterations, and new construction is tailored to fit this policy. It is not an elaborate system and personnel requirements are kept at a minimum. However, we feel that it is extensive enough to give us the necessary control for an efficient operation.

COST REPORTS

We have an I. B. M. system which was originally set up for accounting and payroll purposes but has been extended so that it takes care of several planning, scheduling, and cost control records for the engineering department. Each unit of mill equipment of a material value is assigned a four digit equipment number which is stencilled onto the equipment. These numbers are the basis of our cost records and also are used for filing engineering information, such as new drawings, correspondence, foreign prints, and instruction manuals. The first two digits designate the division in the mill and the last two the piece of equipment in that division. For example, our chip handling facilities are in the 0500 division, digesters in the 1000 division, and no. 7 paper machine in the 4300 division. Standard numbers are used in all divisions to help simplify record keeping. As an example, where the last two digits are 96 this will be instruments in any division. Equipment number record books are also distributed throughout the mill to facilitate correct charges and filing of records. These books are revised monthly, changes stencilled on equipment, and revisions made to files when required.

Each month I.B.M. makes up report sheets showing the charges against each piece of equipment. These charges are broken down as the labor cost by craft, mill storeroom purchases, outside purchases, and labor charges against work orders. One copy of the report is distributed to the operating department superintendents according to the divisions in which they are responsible for costs. The other copy is kept on record in the engineering department for 12 months. This record is useful when making out economic justifications for replacement of equipment, and in detecting "maintenance hogs" so that corrective action other than replacement may also be considered.

V. M. SUTHERLING, Chief Engineer, Longview Fibre Co., Longview, Wash.

WORK CATEGORIES

The work done by our day mechanics falls into the following six categories: (1) breakdowns, (2) routine, (3) instruction slips, (4) tickler cards, (5) equipment shutdowns, and (6) work orders.

An explanation will be given of how the work is handled in each of these classes.

1. Breakdown work requires approximately 10% of our mechanic's time. This is work that has to be taken care of immediately and is usually arranged verbally. It covers such items as broken pipe lines, pump, motor, or bearing failures.

2. Routine work covers regular work such as daily inspections, roll grinding, jordan chipping, and making of spare parts by the machine shop. About 18% of our mechanic's time is spent on this item.

3. Instruction slips take 24% of the mechanic's time and are an informal authorization for small jobs that do not require work orders as defined later. They originate in the various departments of the mill, are initialed by the department superintendents and are passed to the mechanical department where they are distributed to the appropriate craft.

4. Our tickler card system is set up for preventative maintenance and a card is issued for each inspection. A description of the work to be done is typed on each 4 by 6 in. card, along with the equipment number and a routing to the foreman of the mechanical crew that will do the work. On the back of the card the mechanic notes the results of the inspection and signs his name. The card is then routed to personnel interested in the results and then back to file. The cards are issued weekly, semiweekly, monthly, every 3 months, 6 months, or yearly, as specified. They are issued by the telephone operator and a follow-up system is used to assure their return. At the present time we have 450 different inspections on tickler cards and make out approximately 7000 cards per year to cover these inspections. Tickler cards require about 3% of day mechanic's time plus quite a bit of shift mechanic's time.

5. Shutdowns of major pieces of equipment such as paper machines, pulp washers, recovery furnaces, etc., are taken care of by equipment shutdown lists. The preliminary lists are made out by the assistant operation superintendents and passed to the assistant chief engineer. They include all items that the operators want taken care of and their planned length of down time. The assistant chief engineer adds any other items that engineering department has planned and either agrees with the shutdown period or revises it if he gets agreement from the operators. For a normal equipment shutdown of 6 to 12 hr. the mechanical foremen do the detailed planning for their crews. Therefore, we try to get at least 48 hr. notice of these shutdowns so that work lists can be issued and foremen have sufficient time to do a good job of planning. Many times, however, conditions arise that necessitate a shutdown on short notice. Under such conditions we do as good a job of planning as time will permit. On extended shutdowns such as major rebuilds where several days are required, a detailed time schedule is prepared by one of our design engineers after discussion with operating personnel and mechanical foremen. On several occasions we have found that it is advantageous to hold planning meetings with the mechanics who are going to do the work. Equipment shutdowns account for 10% of day mechanics time.

6. The last category of work is work orders. Thirty-five per cent of our day mechanic's time is spent on work orders. This is the largest category, time and costwise, and necessitates the largest amount of record keeping, scheduling, and planning. Work orders are required for jobs that require an estimated 20 man-hr. or more of labor. They also are specifically required for work involving drafting or design, work involving shop manufacture, deferred jobs, major modifications, pump changes, new signs, and additional lighting.

Work order forms are filled in by department superinten-

dents or okayed by them. They show the equipment to be worked on, the number of this equipment, why the work is required, and a description of what is wanted, along with the name of supervisor making the request. They are passed to the assistant mill manager and the mill manager for approval and then to the assistant chief engineer. In most cases he is able to make an accurate enough estimate so that he can add the estimate of man days required for each craft and completion date for design and mechanical departments. The complexity of some work orders necessitates that a design engineer devote a longer period of time to make the estimate of man days. In a few cases the man day requirement for mechanical crews is not filled in until the design work is complete so that a reasonable estimate can be made.

At this point the work order clerk assigns a work order number, enters it in her records, and makes up copies for her files, for the design department, for any involved crews in the mechanical department, and an advance copy for the person originating the work order. If no design is required, the mechanical department copies are sent out. Where design is required the mechanical department copies are held in design department files until design is complete, material is ordered, and drawings and material lists are prepared. In the case of an investigational work order where only design department is involved, the work order is rewritten if the investigation results in a go-ahead job. As each crew completes its part of the work order its copy is returned to the work order clerk. When all copies are returned the completion date is noted and a copy of the work order is sent to the originating department for their approval.

On work orders involving alterations or additions which cannot be considered as repairs according to the Internal Revenue department rulings the work order is charged against a capital account number instead of the regular equipment number.

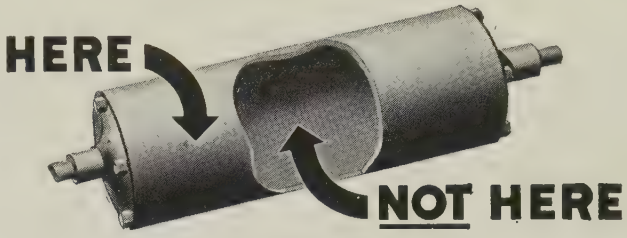
Up to this point we have found that the handling of work orders has developed into a normal record keeping procedure. However, in order to keep our mechanical crews working efficiently we found that we need an average of about 3 months of work ahead of us. This time is needed to permit normal delivery of equipment and to fit the work into normal scheduled equipment shutdowns such as paper machine wire changes. With this size backlog we have about 300 work orders alive at all times. This brings up the problem of which ones to do first. Our first attempt was a priority system where no. 1 jobs were those that must be commenced immediately, or immediately on machine shutdowns. Number 2 jobs were work that must be expedited and warranted considerable overtime. Number 3 jobs were normal work covered by work orders, and no. 4 jobs were deferred projects. This system started out okay, but it soon developed that practically all of the jobs came out with a no. 3 priority and the person who yelled the loudest got his jobs done first.

For the past 2 years we have been holding work order scheduling meetings at 3-week intervals. At these meetings we discuss work load and decide which work orders should be pushed during the following 3 weeks. Present are the mill manager and his assistant, the pulp mill superintendent, paper mill superintendent, chief engineer and his assistant, and the mechanical superintendent and his assistant. We have found that from 15 to 30 work orders should be kept on this push list. Other mechanical crew time available for work orders is spent on other work orders according to specified completion dates. We always try to have sufficient design engineers employed so that design work is ahead of the mechanical crews. You can't afford to have mechanics standing around waiting for drawings or other information.

ADDITIONAL I.B.M. REPORTS

Before closing four other monthly reports that we get from the I.B.M. department which enable us in engineering to plan our work should be mentioned.

IT'S TEMPERATURE



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Every paper mill man knows that water-logging, inside film or air-binding can cause a wide variation between the inside and the outside temperatures of drying rolls. And its the surface temperature on the outside of the rolls that dries the paper. You can locate any off-temperature roll in the train quickly and easily with a Cambridge SurfacePyrometer. This accurate, convenient instrument may be used on still or moving rolls. The convenient Extension Model enables you to reach both nearby and inaccessible rolls.

Send for Bulletin 194SA

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CAMBRIDGE

SURFACE PYROMETERS

1. A master list of all alive work orders listed numerically and showing man days spent and estimated man days to complete.
2. A numerical list of all work orders that were completed during the past month and the man days of labor per craft for each. One important use of this list is to clear the mill storeroom of any material that was left after the work orders were completed. Each item purchased for a work order is marked with the work order number as well as charge number.
3. A master list of all live work orders listed according to craft. One set is sent out to the foreman of the various crews shortly after the first of the month. They use it during the month and make any adjustments of estimated man days that they can substantiate. Just before the end of the month any revised estimates are passed to I.B.M. for including in next month's master lists.
4. A report of work load. This report shows by crew the number of man days of work orders scheduled for the next 4 months and whether or not any man days are available during this period for additional work. The same information is shown for the previous 3 months so that a trend is established. This report is used as a guide for adjustment of mechanical crew strength.

CONCLUSION

This discussion has indicated that with our system of planning work the office handles the broad planning and we rely on our mechanical foremen to do a good job of the detail planning for the crews. The importance of good foremen and supervisors can't be stressed too much. They are the heart of any organization.

Presented at the Thirteenth Engineering Conference of the Technical Association of the Pulp and Paper Industry, Portland, Ore., July 28–Aug. 1, 1958.

Mechanics of Latex Impregnation of Paper

RICHARD C. HOCH

In this paper the author will present some fundamentals of off-the-machine latex impregnation of paper, dealing specifically with the types of saturating paper, the latexes, resins, and compounding ingredients, techniques of controlling pickup, and the use of latex impregnated papers in the pressure sensitive tape and sandpaper fields.

The saturating grades of paper used in this field have several general characteristics which are: (1) long, lightly beaten fibers, (2) high porosity, (3) good absorptivity, and (4) pH between 6 and 8.

Usually the papers are quite bulky because compacting the paper by heavy calendering reduces porosity and impairs the saturating qualities. Sometimes a light calendering is given the paper to smooth the surface and lay down loose fibers, but heavier calendering is reserved for the paper after treatment with latex.

The fibers in these papers can be softwood, preferably from northern or western forests, some varieties of hardwood; old rope; Manila hemp; synthetic fibers, such as rayon, polyester, and nylon; and combinations of wood pulp with these longer fibers. The chemical process used on the wood pulp is either sulphite or kraft, and many times blends of a sulphite and a kraft pulp are used. A high percentage of alpha-cellulose is present in these pulps.

Because of their lower price, papers made with wood pulp enjoy the bulk of the market for saturating papers, and in the majority of cases the properties of the finished product are entirely adequate. But for applications in which superior tensile strength, tearing strength, folding endurance, abrasion resistance, dimensional stability, and ability to be sewn are required, the longer, stronger fibers are used. For high tensile tape backings rope papers are used. For high tearing strength shoe stay material a Manila hemp paper or a synthetic fibered paper can be used. For dimensional stability, folding endurance, abrasion resistance, and ability to be sewn synthetic fibered papers show promise. In many applications latex impregnated papers replace cloth, and for this reason high priced fibers and expensive binders can be used.

In evaluating papers as bases for latex impregnation it is important to gain as much information as possible about the paper before and after impregnation. First the raw paper is tested for caliper, basis weight, density, porosity, pH, water absorptivity, dry and wet tensile, elongation, Elmendorf tear, and burst, and then it is floated on a latex saturant adjusted to the solids content necessary to obtain the desired degree of impregnation. For a satisfactory saturating rate the paper should be completely wetted in 5 sec. The excess latex is then removed by one of the following methods: (1) squeeze rolls, (2) suction, (3) air pressure, and (4) scrapers.

Of these methods squeeze rolls are used most commonly and a variety of innovations can be employed. Thus, two rubber rolls, two steel rolls, or a rubber and steel roll are used. In cases where the saturant is very unstable and coagulates on the squeeze rolls requiring numerous clean-up periods, one of the other methods of removing the excess saturant can be used. With these latter methods it is desirable that the paper have some wet strength.

The impregnated paper is then dried on a circulating air or infrared oven, festoon, or drying cans to a moisture content of 1 to 3% and then tested for dry and wet tensile, elongation, Elmendorf tear, Finch edge tear, burst, internal bond, water absorption, porosity, and water penetration.

Natural rubber latex was the first rubber polymer to be used as a saturant for paper. While this latex imparted excellent tearing strength and resilience to paper, the latex had several disadvantages, such as large particle size which limited penetration into paper, poor resistance to oils, inherent tackiness unless cured, and unstable supply because all the latex had to be imported. Natural rubber latex is still used as a saturant today, and the largest fields of use are in shoe products and artificial leather.

With the invention of neoprene a saturant was available which would overcome natural rubber's poor resistance to oils and more uniform, smaller particle size aided penetration into the paper. Neoprene impregnated papers are characterized by good tensile strength and tear, abrasion resistance, and resilience. Probably the most serious objection to neoprene in paper is poor aging attributed to the evolution of hydrogen chloride causing a tendering of the cellulose. By properly compounding neoprene with an acid acceptor, such as zinc oxide or magnesium oxide and a good antioxidant, degradation of the cellulose can be minimized. One of the biggest uses for neoprene-impregnated paper today is in the gasket field.

The greatest advance in latex impregnation of paper took place with the use of butadiene as a starting material in emulsion polymerization. Combined with styrene to form butadiene-styrene copolymers and combined with acrylonitrile to form butadiene-acrylonitrile copolymers, butadiene became an indispensible monomer in the GR-S and GR-N program under government supervision. After World War II up to the present time these latexes have gained the major share of the market for latexes to be used in paper impregnation. These latexes imparted better flexibility and internal bonding strength to paper as well as being easier to compound and handle in the saturating operation. With the budadiene-styrene latexes materials were available at a uniform price well below that of other types of latexes on the market. The butadiene-acrylonitrile latexes were higher in price than other types of latexes, but these latexes imparted superior oil resistance, good performance at a temperature up to 300°F. and excellent over-all strength to paper.

Other latexes based on acrylic acids, acrylic esters such as methyl acrylate, ethyl acrylate, methyl methacrylate, and others, polyvinyl chloride, vinylidene chloride, polyvinyl acetate, and others have found specialized uses. Of special mention are the acrylate polymers. Because of their excellent aging properties, good color stability, and retention of properties under normal aging conditions, the acrylates qualify for products where permanence is desirable. In the future as the prices on acrylates are reduced, one can expect more emphasis on acrylate polymers as saturants for paper.

In some cases latexes can be used unmodified as saturants, but in the majority of cases the latexes need to be compounded with reinforcers, plasticizers, fillers, antioxidants, sulphur, accelerators, zinc oxide, sequestering agents, waxes, pigments, stabilizers, wetting agents, resins such as phenol-formaldehyde, resorcinol-formaldehyde, urea-formaldehyde, melamine-formaldehyde, terpenes, and alkyds. Reinforcers are used to increase tensile strength and modulus. Plasticizers soften the polymeric saturants for additional flexibility and better low temperature properties. The chief function of fillers is to lower cost. Antioxidants and sequestering agents help retard oxidation and prevent premature degradation of the unsaturated polymers. The sequestering agents play a unique role in tying up copper, manganese, cobalt, nickel, iron, and other cations present in the paper, latex, or water of dilution which would have a catalytic effect on the oxidation rate of rubbers such as natural rubber, butadiene-styrene rubber, and butadiene-acrylonitrile rubber. Sulphur, zinc oxide, and accelerators are used as curing agents particularly with natural rubber for improved tensile strength, reduced surface tack, better aging at high temperatures, and better solvent resistance. Waxes improve water resistance, and aid in the prevention of blocking in die cutting operations.

Richard C. Hoch, Technical Director, Endura Corp., Quakertown, Pa.

Stabilizers prevent premature coagulation of the rubber particles and aid in minimizing build-up of rubber on the squeeze rolls. Wetting of the paper with the saturant is aided by the use of wetting agents. Pigments are used to color the paper. The thermosetting resins are used as a means of developing wet strength as well as to improve the performance of the paper at temperatures above 250°F. Alkyds and terpenes find application where a degree of plasticization is required. In many cases a combination of the compounding ingredients is used to gain a number of special properties.

Latex impregnated papers are used in artificial leather, shoe products, printing bases, gaskets, backings for gummed tapes, backings for abrasive products, and backings for pressure sensitive tapes. In this paper we shall deal specifically with the last two applications.

In the making of abrasive paper for automotive finishing and other sanding applications there are five steps involved which are as follows:

1. Impregnation of an absorptive paper with a synthetic rubber latex.

2. Coating of the dried impregnated paper with a barrier coat.

3. Coating the uncoated side of the paper with a nonslip backsize coating.

4. Application of an adhesive on top of the barrier coat and embedding the abrasive, silicon carbide or aluminum oxide, in the adhesive.

5. The final step is a top coat over the abrasive to lock in the abrasive.

Since the latex impregnated paper is taken through four coating operations, it is imperative that the paper have a very smooth, flat surface on which coatings will flow perfectly. It is equally important that the paper is very flexible initially because the coatings cause a good deal of stiffening. In addition to these properties the paper must be tough in both the wet and dry states. It must have a degree of water resistance so that the abrasive product will pick up some water but not an excessive amount to become somewhat more flexible when dipped in water. It must age well during the long curing cycles in the coating operations as well as on the shelf. It is also believed that good delamination resistance is a desirable property particularly where there is a good deal of flexing as during a sanding operation.

Since there is a variety of papers used as backings for pressure sensitive tapes, the properties required vary with the application. The make-up of a masking tape requires an impregnated paper as a backing, a backsize, or release coat on one side, a tie coat on the uncoated side, and a pressure sensitive adhesive over the tie coat. Inasmuch as the tape is wound into rolls, the adhesive must be bonded well to the tie coat to avoid transfer of the adhesive to the backsize coating during unwinding of the roll in use. Also, the adhesive must release easily from the release coat to avoid pick-off of the release coat or delamination of the paper. In general, the most important property of the latex impregnated paper backing is internal bonding strength or resistance to delamination. In masking tapes the backing must also be solvent resistant, resistant to degradation at temperatures used to bake paints, conformable, and have enough stretch to go around curves without tearing. The most important property next to internal bond on packaging or holding tapes is good tensile strength. For carton sealing tapes good wet and dry tensile strength is required. For protective masking flexibility and good stretch are important factors. In many cases these tapes are subjected to long storage periods at high humidity and temperatures over 100°F., and for this reason the backings should be affected very little by severe atmospheric conditions.

Presented at the Thirteenth Plastics-Paper Conference of the Technical Association of the Pulp and Paper Industry, Springfield, Mass., Oct. 20–22, 1958.

First Floor versus Second Floor for Paper Machine Installation

RAY MARSH

In recent years, the engineer in pulp and paper mill work is becoming more and more important to management, not only as an engineer, but as a consulting economist. Many times the engineer is called upon by management to answer questions relating to economics, the answers to which seem fairly obvious to the engineer, but to make a satisfactory explanation and present the figures to substantiate sometimes presents a problem.

An example of this type of question was demonstrated last year when the chief engineer of a paper mill called and asked for help on just such a problem. His company was planning on installing another paper machine in their mill. This additional machine would be producing a different type of product than the existing mill was then manufacturing. Thus, the new machine was not required to be set up as an integral working unit with the existing mill, but could be set up as more of a separate operation except for the storing and shipping area. Also, there was a desire to allow for the addition of new machines to the existing mill between the new and old operation. The question which management had brought up was the feasibility and possibility of the savings which might be effected by installing the new paper machine on the ground floor or what corresponded to the basement floor of the existing mill.

Some engineers connected with pulp and paper work would say immediately that they believe it is better to install a paper machine on the second floor. Such an answer is entirely reasonable and may, to the engineer, by sufficient, but to management, who has the responsibility to its board of directors to watch over the investment angle, there is a necessity for more detailed facts and figures. The object of this paper is to try to place in the hands of the engineer some of the tools needed to work with to solve such a problem.

A careful search of records of TAPPI bibliographies and current issues of Tappi and other pulp and paper periodicals failed to disclose that any particular economic studies had been made to evaluate the relative installations of paper machines.

A true analysis of all the advantages and disadvantages of installing a machine on the first (basement) or second normal operating) floor would require a lengthy report. This is because of the large number of tangible and intangible items to be considered. To keep this paper within the allotted scope of time, it will be necessary to omit some of the items and cover only those which are considered to be of most importance.

In order to prepare a comparison of the two basic types of machine installations such as considered here, it was necessary to make layouts of the machine and the various auxiliary equipment required for a complete manufacturing unit. The piping and electrical runs had to be laid out and rough material take-offs and labor estimates made.

The first of two types of construction for installation of a paper machine to be discussed, is to mount the machine on the first or basement floor. We have made a cost analysis of most of the factors involved and, although not entirely complete, we believe that the most important ones have been covered.

Some of the factors to be considered are a follows: (I) the distance that the major controls must be installed with reference to the paper machine, (II) the added cost of piping necessitated by moving the auxiliary equipment at some distance from the machine, (III) the additional floor space

Ray Marsh, Pulp and Paper Contract Engineer, Walter Kidde Engineers—Southwest, Inc., Houston, Tex.

required to install equipment which would normally be set in the basement, and (IV) the added mechanical equipment required to take the place of the use of gravity in some operations.

There are some items to be considered which are not direct investment costs, but are operational costs, which are as follows: (A) cost of added labor in one type of operation versus the other, (B) the efficiency of operation of the paper machine itself, (C) power requirements to operate necessary added equipment, and (D) added maintenance cost on extra equipment.

All of these items will be taken up in more detail to show actual cost estimates for comparisons.

I. In connection with the moving of control rooms, we have prepared, in conjunction with a client, a very good study of the actual cost per foot for such work. This study revealed some very interesting facts which should be noted. For example, to move a seven-section motor control center a distance of approximately 130 ft. farther from the machine than the usual location cost over $14,000, or over $100 per ft. This control center was for the small motors on the wet end of the machine.

In contrast, the cost of moving seven-section motor control center for the large motors on the wet end approximately the same distance was only slightly over $5000, or $42.60 per ft. To move a 3000 kva. limit amp line-up this distance cost $4200, or $30 per ft. The cost of moving the wet end sectional drive panel was over $14,000, or $111 per ft., and the dry end panel was slightly over $8000, or $75 per ft. These figures show that locating electrical equipment at some distance from the machine can run into great sums of money. From this study the actual cost of moving the controls is from $30 to $111 per ft., or an average $70.50 per ft. per unit. Thus, if the control centers were located 100 ft. farther from the machine, which our layouts showed was required, the cost for moving the seven major components would be $49,350.

II. The cost of piping required in locating mechanical equipment at some distance from the paper machine due to the loss of the basement must be considered. In order to arrive at a fair cost estimate of an installation of this type, it was necessary to make mechanical layouts of equipment in the two categories and compare the labor and material required to pipe up the various equipment. By doing this, we were able to arrive at a cost per foot for moving this mechanical equipment of $240. Thus, if the auxiliaries were required to be located at an added distance of 100 ft. from the machine due to the loss of basement room, the increased piping cost would be $34,000.

III. The added floor space required for equipment normally located in the basement was also found by using the alternate layouts of equipment. Our layouts showed that approximately one third of the area of the basement which would have been available for equipment installation must be provided as extra floor space. The cost of this additional space would vary with the type of construction, but based on our hypothetical case, we calculated the cost to be approximately $9 per sq. ft. The additional area, which we considered necessary, was 7200 sq. ft, and the total cost for added area would be $64,800.

IV. The additional mechanical equipment required for all-one-floor installation was considered to be four extra pumps, which would cost a total of approximately $25,000.

In order to install the paper machine on the second floor, the building cost due to the heavy supporting columns would be greatly increased. This cost, according to our estimates, would be $101,000.

The comparative operational costs for the two types of construction being discussed here are more difficult to estimate than the investment cost. There is room for more varied opinion as to the various cost items and methods to be used in the estimation of such costs. Some of these operational costs are discussed as follows:

(A) The added labor cost for the basement type of installation would involve at least two extra men per shift to gather the broke and feed it into the disintegrater. Based on three shifts, the requirement would be six men per day, or 2160 man days per year. Thus, the added cost for this operation would be $31,000 per year.

(B) Efficiency of operation of one type of installation over another can be a questionable item. We have considered that the less efficient operation of the machine due to basement installation would result in a loss of production of approximately $5000 per year.

(C) The added power requirements for extra equipment would be approximately 200 hp. The cost of this power would then be 200 hp. times 8600 hr. times 5 mills, or $8640 per year.

(D) The cost of maintenance, depreciation, and deterioration would run approximately 10% of the equipment cost, or $2500 per year.

If we make a recap of the costs of the two types of installations discussed here based on a yearly cost using 6% for interest charge on capital investments, we find the following:

First Floor Installation		
(I) Moving controls—$49,350 × 6%	$2960.00	per yr.
(II) Piping costs—$34,000 × 6%	2040.00	per yr.
(III) Added floor space—$64,800 × 6%	3888.00	per yr.
(IV) Added mechanical equipment—$25,000 × 6%	1500.00	per yr.
Additional operating costs per year over second floor installation:		
(A) Extra labor required	$31,000.00	
(B) Loss of production	5,000.00	
(C) Added power requirements	8,640.00	
(D) Maintenance, depreciation, and deterioration on added equipment	2,500.00	
Total additional cost	$57,528.00	per yr.
Second Floor Installation		
Additional cost for second floor $101,000 × 6%	$6,060.00	per yr.
Maintenance, depreciation, deterioration $101,000 × 3%	3,030.00	per yr.
	$9,090.00	per yr.

Thus, it can be seen that there would be a savings of some $48,000 per year by doing the route of a second-floor installation.

In considering an installation of a paper machine on either first or second floor, many more factors can be enumerated which are not listed in this paper. However, the figures obtained from what appeared to be the most important items show that there should be a substantial saving by installing the machine on the second floor. On the basis of the relative cost of these alternates the engineer involved was able to present the case to management and they made the decision to proceed with the second floor installation.

The foregoing has, it is hoped, furnished some ideas as to one approach in developing and presenting to management the economics of a complicated problem, such as deciding on a first story versus second story installation of a paper machine. Upon first look, the author had throught that this would have been solved many times before, but found that there had been very little written on the subject, and we had to feel our way in developing our approach.

Presented at the Thirteeenth Engineering Conference of the Technical Association of the Pulp and Paper Industry, Portland, Ore., July 28–Aug. 1, 1958.

14th Engineering Conference

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Oct. 12–15, 1959

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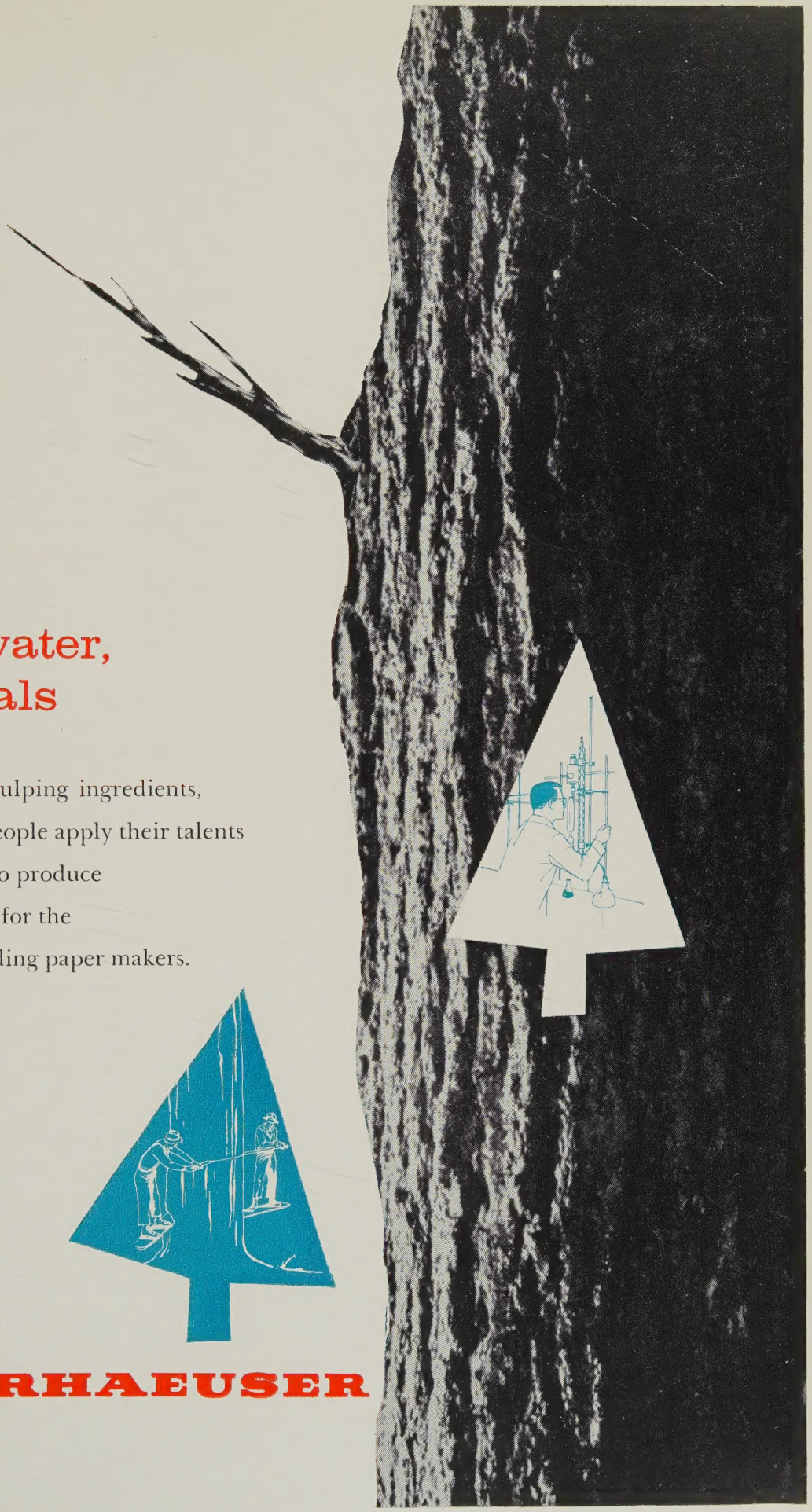

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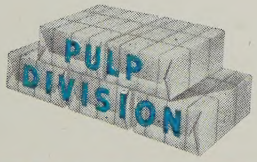

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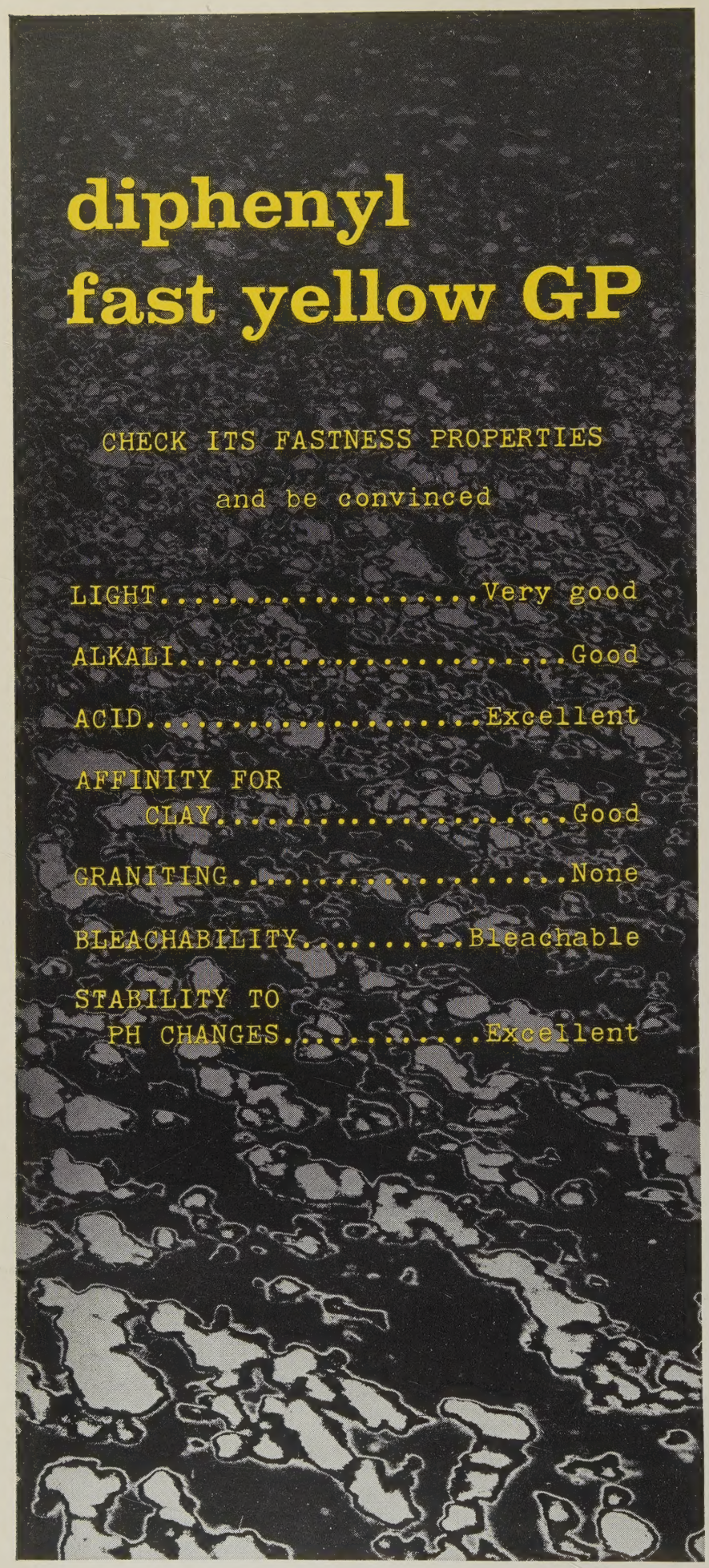

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